The AIR Hurricane Model for the U.S. V1.0.0 as Implemented in Touchstone® 2020

Submitted in Compliance with the 2019 Standards of the Florida Commission on Hurricane Loss Projection Methodology

May 19, 2021

AIR

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Contact Information

AIR is headquartered in Boston with additional offices in North America, Europe, and Asia. For information on our office locations, visit www.air-worldwide.com/About-AIR/Offices/

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Florida Commission on Hurricane Loss Projection Methodology

Model Identification

Name of Model:	AIR Hurricane Model for the United States
Model Version Identification:	V1.0.0
Interim Model Update Version Identification:	
Model Platform Name and Identifications:	Touchstone® 2020
Interim Data Update Designation:	
Name of Modeling Organization:	AIR Worldwide Corporation
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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: Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item)
- Form V-5: Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item)
- Form A-6: Logical Relationship to Hurricane Risk (Trade Secret Item), graphical summaries which demonstrate the sensitivities of the notional sets, contour map and scatter plot associated with distance to coast
- Workpapers 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
- Workpapers 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.

General Standards

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

Relevant Forms:

- *G-1, General Standards Expert Certification*
- *M-1, Annual Occurrence Rates*
- *M-3, Radius of Maximum Winds and Radii of Standard Wind Thresholds*
- *S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year*
- *S-2, Examples of Hurricane Loss Exceedance Estimates*
- *A-3, Hurricane Losses*
- *A-4, Hurricane Output Ranges*
- *A-5, Percentage Change in Hurricane Output Ranges*
- *A-6, Logical Relationship to Hurricane Risk (Trade Secret Item)*
- *A-7, Percentage Change in Logical Relationship to Hurricane Risk*
- *A-8, Hurricane Probable Maximum Loss for Florida*

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

The AIR Hurricane Model for the U.S. projects loss costs and probable maximum loss levels for damage to insured residential property from hurricane events. G-1 Disclosure 2 supports AIR's compliance with Standard G-1.A. by providing a description of how the model operates to produce projected loss costs and probable maximum loss levels.

The model's ability to project loss costs and probable maximum loss levels is demonstrated in Forms A-1, A-4, A-6 (showing modeled loss costs) and A-8 (showing modeled probable maximum loss levels). In each case, example portfolios of insured residential properties are imported and analyzed using the model's stochastic catalog of hurricane events.

Form A-6 contains trade secrets and will be reviewed with the Professional Team (Pro Team). The workpapers and processes used to prepare the example portfolios and generate all forms, including Form A-1, A-4 and A-6 are also considered trade secret and may be reviewed with the Pro Team.

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

AIR 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, 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 Disclosure 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.

AIR's internal documentation, data files, databases, and computer source code are all examples of trade secret information that may be reviewed by the Pro Team as they verify M-, S-, V-, A-, and CI-Standards against the submitted hurricane model.

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

To build and validate the hurricane model and Touchstone platform, AIR's teams utilize various software and tools which are stored and managed from a centralized location on the AIR internal computing network. All data and source code are located in a centralized, model-level file areas on the AIR internal computing network. Software designed to be installed and used on employee workstations is maintained by AIR's Information Technology team and deployed to users' workstations, which are a part of the AIR 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 Disclosure 1, CI-5.B, CI-5.C, and CI-6 Disclosure 1 provide information about software development and validation tools which are maintained on central workspaces on the AIR internal computing network. CI-5 Disclosure 3 lists externally sourced data sets which AIR stores in network locations accessible by relevant staff during model development. CI-6 Disclosure 1 discusses software and tools used in model maintenance and revision. AIR 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, AIR's teams use data sets provided with the ROA, scripts and templates developed internally, all in conjunction with Touchstone. Touchstone is installed on hardware located on the AIR internal computing network. The scripts and templates used to create the forms required for the submission are developed on workstations located on the AIR internal computing network. Workpapers and results used in the final forms are stored in central file areas accessed by relevant staff. AIR will share trade secret details of such workpapers and results with the Professional Team during discussion of G-1 Audit 2 and will demonstrate their compliance with this standard by virtue of being stored in central file areas.

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

AIR prepared Forms M-1, M-3, S-1, S-2, and all Actuarial forms using automated procedures. The 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. AIR will review details of these improved processes with the Pro Team as trade secret information.

Disclosures

1. ***Specify the hurricane model version identification. If the hurricane model submitted for review is implemented on more than one platform, specify each hurricane model platform identifying the primary platform and the distinguishing aspects of each. Demonstrate how these platforms produce the same hurricane model output results, i.e., are otherwise functionally equivalent as provided for in subsection J. Review and Acceptance Criteria for Functionally Equivalent Hurricane Model Platforms, Item 2, under section VI. Review by the Commission in the chapter "Process for Determining the Acceptability of a Computer Simulation Hurricane Model.".***

The current AIR hurricane model being submitted to the Commission for approval is the AIR Hurricane Model for the United States V 1.0.0; Program: Touchstone® 2020. The model being submitted for review is not implemented on more than one platform.

2. ***Provide a comprehensive summary of the hurricane model. This summary should 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 should be complete and must not reference unpublished work.***

Introduction

The AIR 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 AIR Hurricane Model for the U.S. include the most complete databases available from various agencies of the National Weather Service, including the National Hurricane Center. All data is 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 the data flow during an analysis using the AIR Hurricane Model for the U.S.

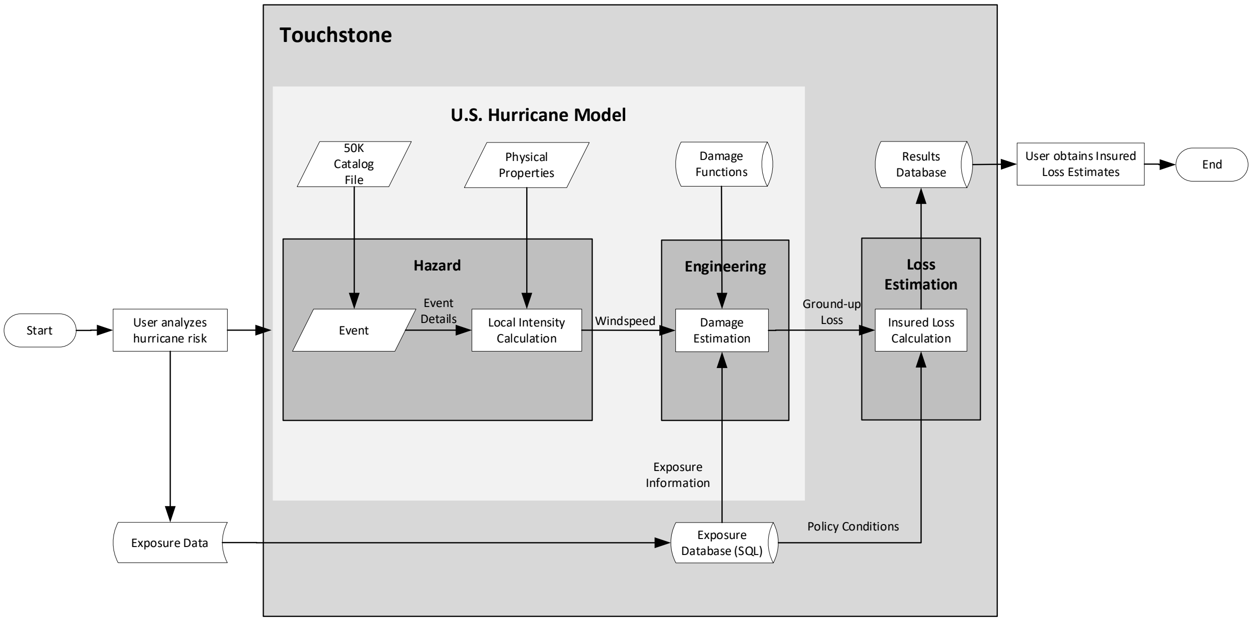

Figure 1. Components of the AIR Hurricane Model for the U.S.

Event Generation Component

This first module of the AIR tropical cyclone model 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 AIR Hurricane Model for the U.S., 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 also accounts for the lack of historical landfalls in certain portions of the coastline.

Bypassing Storms

The AIR Hurricane Model for the U.S. 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 1900–2018. 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. Storms affecting the coast in northern latitudes tend to be larger and faster moving on average. 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. For example, 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.

AIR 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, thus capturing the effect of duration of wind on structures as well as peak wind speed. 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 (GWRF)

The model uses a stochastic 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 (PWF)

The 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

AIR scientists and engineers have developed damage functions that describe the interaction between buildings, both their 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 things being equal. The AIR Hurricane Model for the U.S. 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 AIR damageability relationships incorporate the results of well-documented engineering studies, damage surveys and analyses of available loss data. AIR 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 AIR 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.

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

The interactions among major hurricane model components are illustrated in Figure 2.

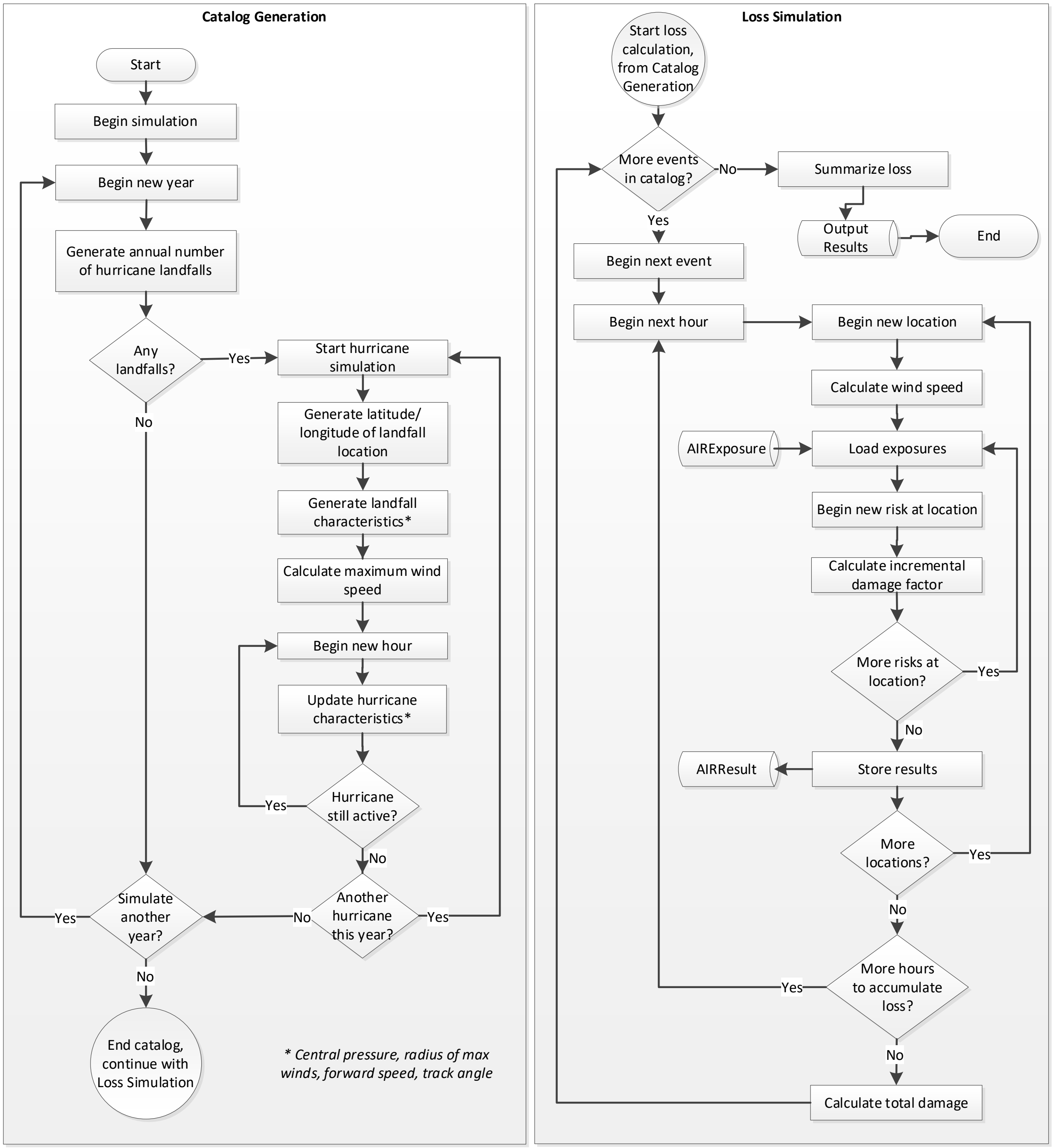

Figure 2. Flowchart of the AIR Hurricane Model for the U.S.

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

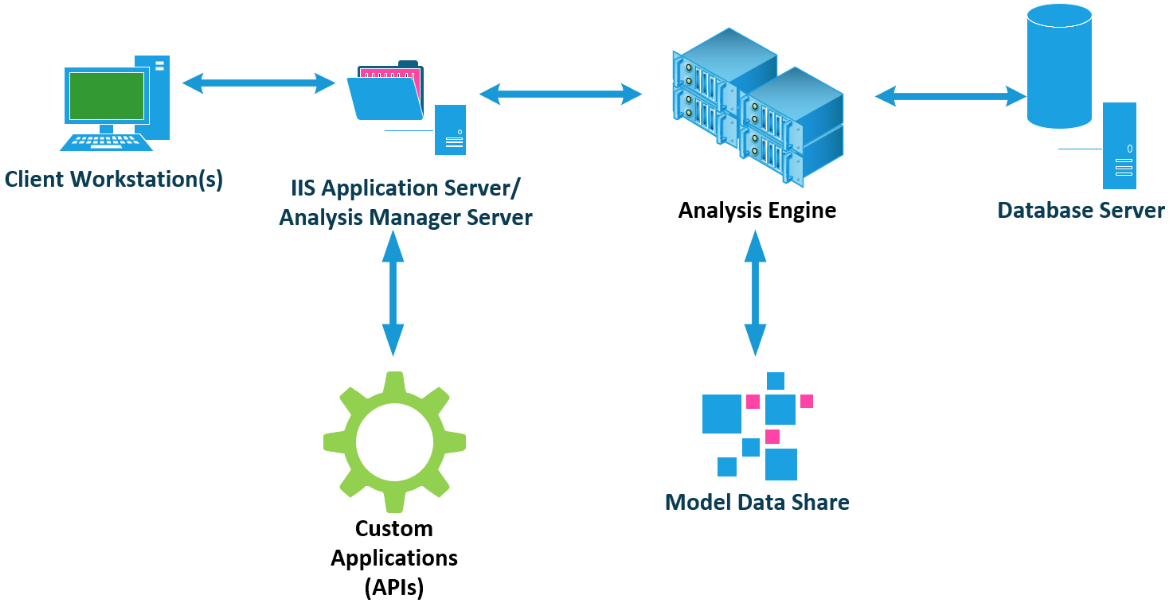

Figure 3. Touchstone Network Organization

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

5. Provide detailed information on the hurricane model implementation on more than one platform, if applicable.

Not applicable.

6. Provide a comprehensive list of complete references pertinent to the hurricane model by standard grouping, using professional citation standards.

References

The following reference materials have been reviewed by AIR staff and used in the development and refinement of the AIR Hurricane Model for the U.S

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

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.

Hurricane Model Changes

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

Event Generation Component (i.e. Catalog)

AIR's historical storm set has been updated to incorporate new events that occurred in 2017 and 2018, as well as to incorporate information from the 2019 version of HURDAT2. 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 previously 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 2020. 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 2020.
- 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 2020.
- The logic of roof age assignment has been updated to assign buildings built within the last 10-20 years to have an "average" roof year built when the roof year built is unknown.

These are technical updates to keep data elements current in the model.

Geographical Updates

Geographic data elements are updated each year. Updates include:

- ZIP Codes have been updated to April 2020, and ZIP dependent databases were updated accordingly.
- The U.S. Census Topological Integrated Geographic Encoding and Referencing (TIGER)/Line data, which supports street level geocoding, was updated to be relevant through 2019.
- AIR's Industry Exposure Database for the U.S. has been updated to be current as of 12/31/2019. The Industry Exposure Database update affects estimated industry losses and resulting demand surge factors.

These are technical updates to keep data elements current in the model.

Other Updates

Other changes made to the previously 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 U.S. Inland Flood, a separate U.S. Hurricane Model v18.0.0 with precipitation induced flooding, Offshore Assets Hurricane, and Wildfire, Australian Earthquake and Tropical Cyclone, Caribbean Earthquake and Tropical Cyclone, China Typhoon, New Zealand Earthquake, European Extratropical Cyclone and Inland Flood.
- Updates to the Touchstone software to improve usability and functionality for clients and their workflows. Updated functionality includes the introduction of premium international geocoding, flexibility in deductible policy logic, upgraded database maintenance procedures, updated format of exported files, and other new software analytics features.

B. Percentage difference in average annual zero deductible statewide hurricane loss costs based on the 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named “hlpm2017.zip” 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 A. are calculated by analyzing the 2017 FHCF data in Touchstone 6.1.0 and Touchstone 2020.

- The overall change in the statewide average annual zero deductible industry residential loss cost is a 0.3% increase in loss cost.
- Event Generation Component: These updates have resulted in a 0.3% decrease in losses.
- Vulnerability Component: These updates have resulted in a 0.1% increase in losses.
- Geographical or Other Data Update: These updates have resulted in a 0.5% increase in losses.

Lost Cost Differences: Maps by County

C. Color-coded maps by county reflecting the percentage difference in average annual zero deductible statewide hurricane loss costs based on the 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named "hlpm2017.zip" for each hurricane model component change:

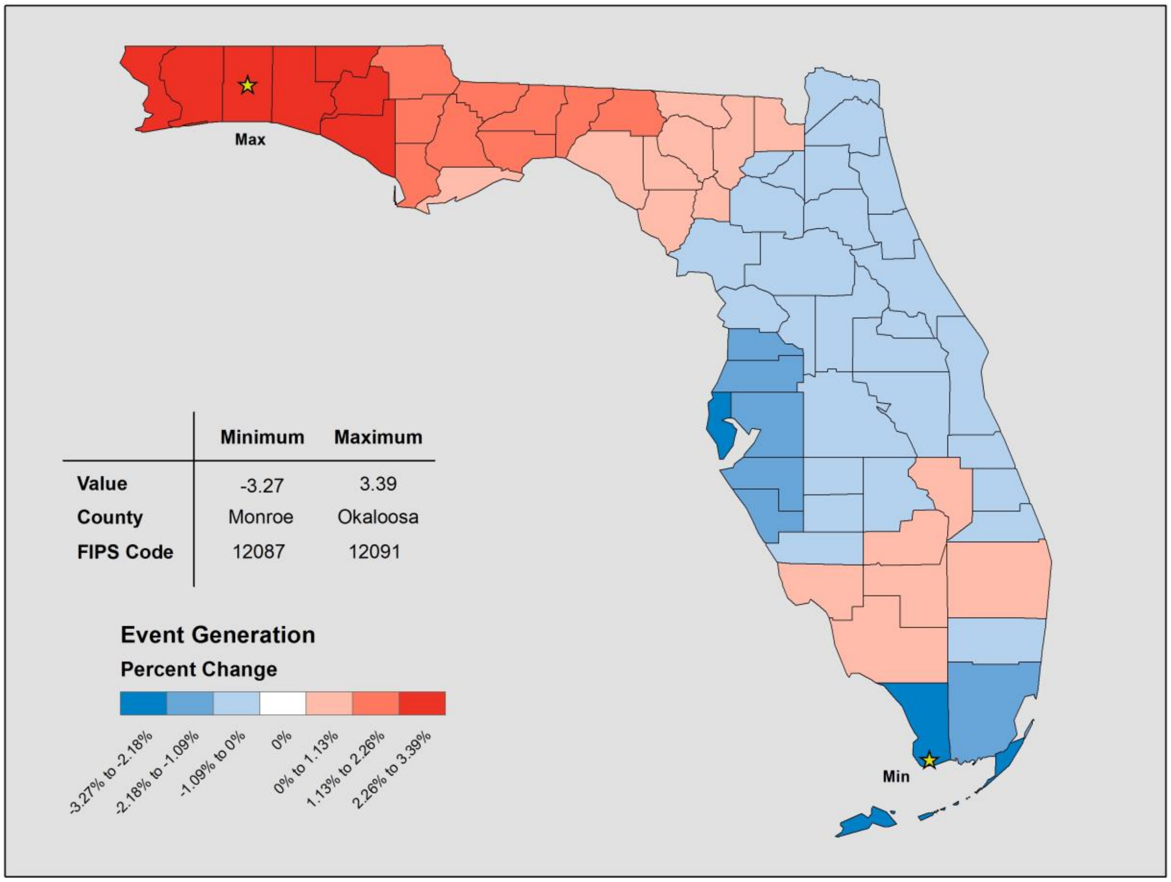
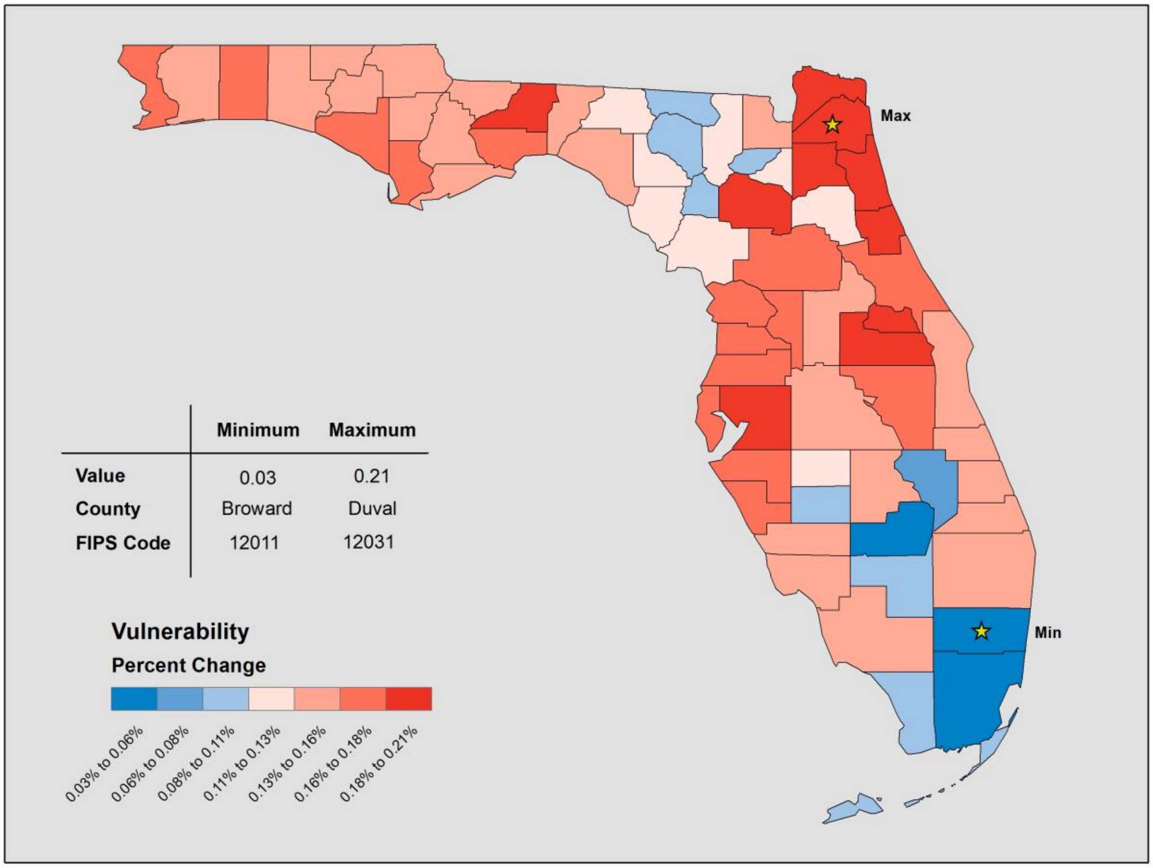


Figure 4. Event Generation Percentage Impact on Average Annual Zero Deductible Statewide Loss Costs



	Minimum	Maximum
Value	0.03	0.21
County	Broward	Duval
FIPS Code	12011	12031

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

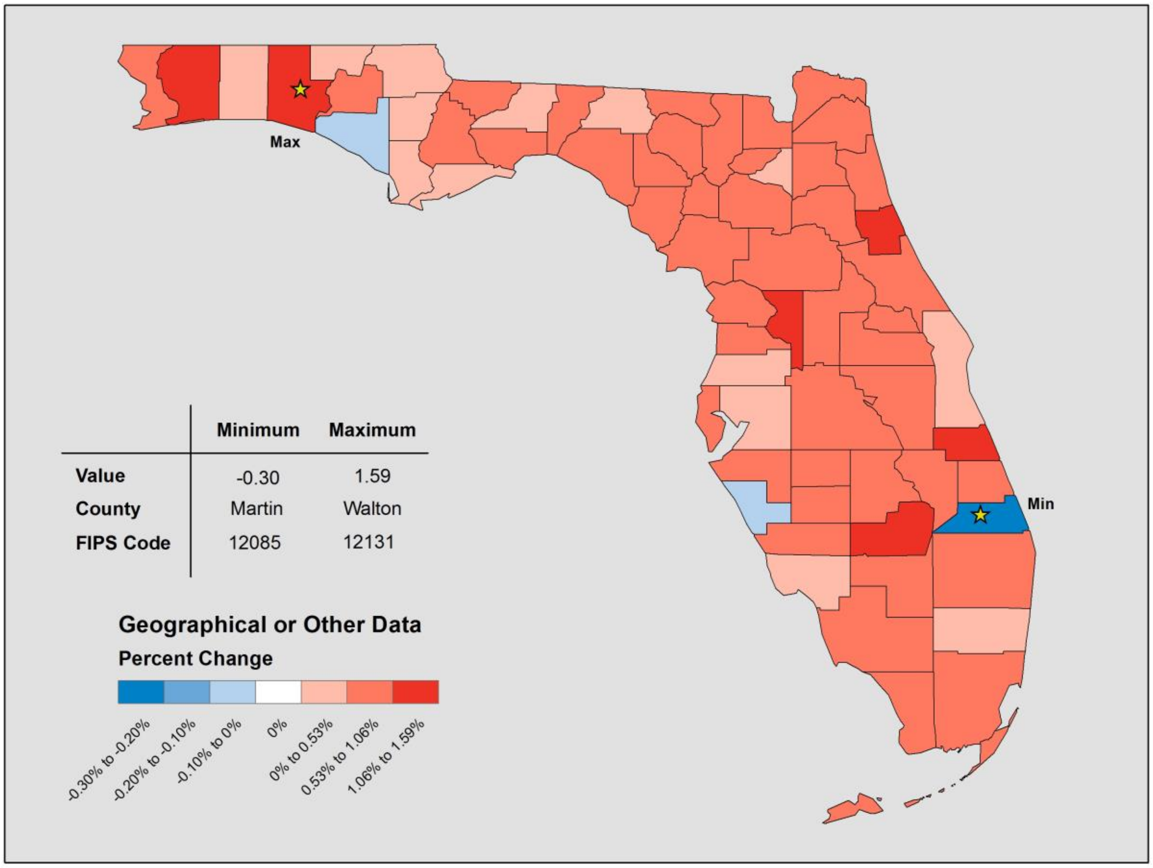
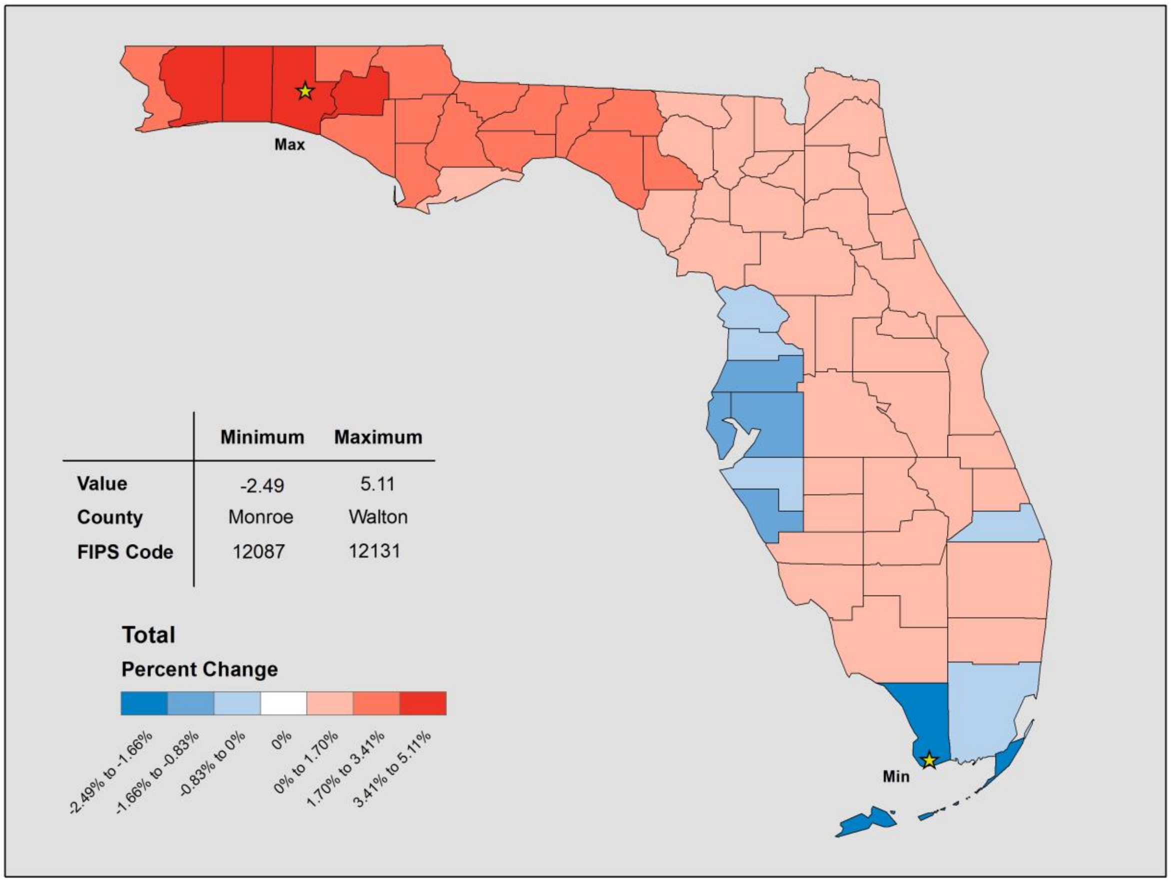


Figure 6. Geographic or Other Data Percentage Impact on Average Annual Zero Deductible Statewide Loss Costs

D. Color-coded map by county reflecting the percentage difference in average annual zero deductible statewide hurricane loss costs based on the 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named "hlpm2017.zip" for all hurricane model components changed.



	Minimum	Maximum
Value	-2.49	5.11
County	Monroe	Walton
FIPS Code	12087	12131

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

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 2021 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 of the Hurricane Model

Relevant Forms:

- *Form G-1, General Standards Expert Certification*
- *Form G-2, Meteorological Standards Expert Certification*
- *Form G-3, Statistical Standards Expert Certification*
- *Form G-4, Vulnerability Standards Expert Certification*
- *Form G-5, Actuarial Standards Expert Certification*
- *Form G-6, Computer/Information Standards Expert Certification*

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.

AIR employs a large, full-time professional staff 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.

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

All modifications to AIR’s currently accepted model and all hurricane model submission documentation have been reviewed by modeler personnel or independent experts as indicated in Table 1.

All AIR staff and independent experts abide by the standards of professional conduct adopted for their respective professions.

Table 1. AIR Modeler Personnel and Independent Experts

Name	Professional Discipline	Years of Professional Experience	Education Level	Qualification
Uhlhorn, Eric	Meteorology and Physical Oceanography	27	Ph.D., University of Miami	Advanced degree
Huang, Suilou	Statistics	27	M.S. Statistics, University of Rhode Island (Ph.D. Oceanography, University of Rhode Island)	Advanced degree
Friedland, Carol*	Civil Engineering	13	Ph.D., Louisiana State University	Advanced degree, licensed P.E.
Gotham, Stacey	Actuarial Science	32	B.A. Mathematics, Rutgers College	FCAS, MAAA
Pourghasemi, Narges**	Computer Science	22	M.S., Computer Science, University of New Hampshire	Advanced degree

*Independent expert Dr. Carol Friedland, Ph.D., P.E., C.F.M., consulting engineer and professor at the Louisiana State University, reviewed the vulnerability components of the AIR Hurricane Model for the U.S.

**Independent software engineer Ms. Narges Pourghasemi reviewed the software engineering components of the AIR Hurricane Model for the U.S.

Disclosures

1. *Modeling Organization Background*

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 second-tier subsidiary of Verisk Analytics, Inc., a publicly held company. AIR has subsidiaries or offices in San Francisco, London, Munich, Hyderabad, Beijing, Tokyo, and Singapore. AIR is the owner of AIR Worldwide Limited in London, Verisk Analytics India Private Limited in India, Verisk Analytics GmbH in Germany, and Verisk Analytics Japan LLC in Japan.

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 AIR Hurricane Model for the U.S. is developed, maintained and enhanced by full-time professional staff employed by AIR.

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 AIR Hurricane Model for the U.S. is developed exclusively by full-time professional staff employed by AIR.

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

AIR provides natural catastrophe, mortality, supply chain, terrorism, casualty, and cyber risk assessment and management products and services to primary insurance companies, reinsurers, intermediaries, involuntary markets, state funds and other insurance industry organizations such as ISO and the 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 (AIR Loss Estimates in Real Time) to give information and, for certain events, loss estimates to clients and interested parties.

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.

AIR has never been involved in litigation or been challenged by a statutory authority with respect to the credibility of the AIR Hurricane Model for the U.S.

2. Professional Credentials

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***

Staff and Consultants

The individuals currently involved in the primary development of the model are listed in the following tables. All the individuals named are full-time employees of AIR.

Table 2. Professional Credentials (G-2. A.1-5)

2.A.1. Meteorology: Name, Education	Years at AIR	Relevant Experience
Boyko Dodov Ph.D., Hydrology, University of Minnesota	15	Dr. Boyko Dodov is a Vice President and Director of Atmospheric and Flood Modeling in AIR's Research and Modeling group. He received his B.S. in Hydrogeology from the Higher Institute of Mining and Geology in Sofia, Bulgaria, and his Ph.D. in Civil Engineering - Hydrology from the University of Minnesota. Boyko is the author of numerous peer-reviewed papers and presentations related to the implementations of mathematical and statistical approaches to stochastic simulation of weather and climate phenomena.
Phillip Jue B.S., Atmospheric Sciences, University of Illinois, Champaign	6	Mr. Jue is a scientist, joined AIR in 2014 first as an intern and in 2015 as a full-time employee. Phil has a bachelor in Atmospheric sciences from the University of Illinois Champaign. Mr Jue has been working on calibration of historical events on select models here at AIR. Most recently he has been leading the real-time effort during hurricane seasons.
Sylvie Lorsolo Ph.D., Geosciences (Atmospheric Sciences), Texas Tech University	8	Dr. Lorsolo, a Senior Scientist, joined AIR in 2012 as an Atmospheric Scientist in the Research Department. Most recently, 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. Prior to that, Dr. Lorsolo was a Research Assistant at Texas Tech University, where she studied hurricane structure at landfall and was responsible for field experiment design for land falling tropical cyclones. She also conducted damage surveys after hurricane landfall and tornado events. In addition, Dr. Lorsolo earned her Ph.D. in Geosciences from Texas Tech University.
Jeff Strong Ph.D., Atmospheric & Oceanic Sciences, Princeton University	1	Dr. Strong joined AIR in 2019 as a Scientist in the Research Department working on tropical cyclone hazard modeling. Dr. Strong came to AIR from the Lamont-Doherty Earth Observatory of Columbia University where, as a postdoctoral research scientist, he collaborated with the NASA Goddard Institute of Space Studies to develop the next-generation of global tropical cyclone models. Prior to that work, Dr. Strong was employed as a postdoctoral research scientist at the Scripps Institution of Oceanography at UCSD studying the simulated impacts of aerosols on global tropical cyclone development. Dr. Strong earned his Ph.D. and M.A. from Princeton University and a dual B.S. in Environmental Science and Mathematics from the University of Virginia.
Eric Uhlhorn Ph.D., Meteorology and Physical Oceanography, University of Miami	5	Dr. Uhlhorn joined AIR in 2015 as a Principal Scientist in the Research Department. He most recently worked as a Meteorologist for NOAA/Hurricane Research Division, where he used in situ and remote sensing observational data from aircraft to gain better understanding of tropical cyclone surface wind field structure. Prior to that, he worked as a Senior Research Associate III for the Cooperative Institute for Marine and Atmospheric Studies for the University of Miami. Dr. Uhlhorn earned his Bachelor of Science Degree in Meteorology from Florida State University, his Master of Science Degree in Physical Oceanography from Florida Institute of Technology, and his Ph.D. in Meteorology and Physical Oceanography from the University of Miami.
Richard Yablonsky Ph.D., Oceanography (Physical), University of Rhode Island	6	Dr. Yablonsky joined AIR in 2014 and is currently a Senior Scientist in the Research Department, where he leads the Storm Surge Team. Since joining AIR, he has been directly or indirectly involved in a variety of projects, including tsunami hazard modeling and all aspects of tropical cyclone hazard modeling (storm surge, precipitation, frequency, track, and intensity). Previously, Dr. Yablonsky worked as a Marine Research Scientist (2013-2014) and a Marine Research Associate (2009-2013) at the University of Rhode Island's Graduate School of Oceanography in Narragansett, RI, specializing in modeling air-sea interaction in tropical cyclones.

2.A.1. Meteorology: Name, Education	Years at AIR	Relevant Experience
		He has also held a Visiting Scientist Appointment at the Developmental Testbed Center in Boulder, CO (2014). Dr. Yablonsky obtained a Ph.D. in Oceanography from the University of Rhode Island (2009) and three degrees from North Carolina State University: M.S. in Atmospheric Science (2004), B.S. in Meteorology (2002), and B.A. in Chemistry (2002).
Ying Zhou Ph.D., Environmental Science, SUNY College of Environmental Science and Forestry	1	Dr. Zhou joined AIR as a Scientist in the Research Department. Previously, Dr. Zhou was a Consultant for FM Global, where she worked on the tracking and detection of extratropical cyclones. Prior to that, Dr. Zhou was a Research Assistant at SUNY College of Environmental Science and Forestry, where she studied the impact of extratropical cyclones, wildfires, anthropogenic and natural emissions on tropospheric ozone. In addition, she maintained atmospheric instruments to monitor air quality. Dr. Zhou earned her Ph.D. in Environmental Science from SUNY College of Environmental Science and Forestry.

2.A.2. Statistics: Name, Education	Years at AIR	Relevant Experience
Suilou Huang Ph.D., Oceanography, University of Rhode Island	8	Dr. Huang is a Senior Scientist II in the Research Department, Statistics and Applied Mathematics group, at AIR. Since she joined AIR in 2013, she has been using her statistics expertise, data analysis, and computer programming skills in a variety of projects such as developing the Canada Tropical Cyclone catalog, and the U.S. and Australia Wildfire models; updating the U.S. Hurricane catalog, providing support to the AIR Hurricane Model for the U.S. submissions to the Louisiana State Hurricane Commission and FLHCM; and providing client support. She also gives statistical training courses to AIR employees. Prior to joining AIR, Dr. Huang worked as an associate technical staff member at MIT Lincoln Laboratory, a guest scientist at Woods Hole Oceanographic Institution, and a research scientist/adjunct faculty member at New Mexico Institute of Mining and Technology. Dr. Huang holds a B.A. in Chemistry from Sun Yat-Sen University, China, an M.S. in Statistics from the University of Rhode Island, and a Ph.D. in Oceanography from the University of Rhode Island.
Susan Tolwinski-Ward Ph.D., Applied Mathematics, University of Arizona	7	Dr. Tolwinski-Ward is a Principal Scientist at AIR, with a background in data-model fusion and uncertainty quantification. She has been modeling the statistical climatology of tropical cyclones at AIR since 2013. She holds a Ph.D. in Applied Mathematics from the University of Arizona with a minor concentration in Atmospheric Sciences. Prior to beginning work at AIR, 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.

While many outside experts have been consulted on various aspects of the vulnerability functions, the primary full-time employees currently involved in model development are:

2.A.3. Vulnerability: **Name, Education**	**Years at AIR**	**Relevant Experience**
Sarah Bobby Ph. D., Civil and Environmental Engineering and Earth Sciences, University of Notre Dame	5	Dr. Bobby joined AIR in 2015 as an Engineer 1 and Manager in our Research Department. Prior to working with AIR, 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.
Jayanta Guin Ph.D., Civil Engineering, State University of New York, Buffalo	23	Dr. Guin is Executive Vice President and Chief Research Officer responsible for operational and strategic management of the AIR Research and Modeling team. Under his leadership, the team has expanded the global coverage of natural catastrophe models and continues to enhance existing models. He has more than ten years of experience in probabilistic risk analysis for natural catastrophes worldwide. Dr. Guin has led the research effort on a number of capital markets transactions that involved transfer of risk due to earthquakes, cyclones and windstorms. Prior to his graduate studies, he worked as a structural engineer with a leading design consultant in India. Dr. Guin received his B.S. in Civil Engineering from Jadavpur University in India. He earned his M.S. and Ph.D. in Civil Engineering from the State University of New York, Buffalo, with a specialization in dynamic soil-structure interaction and computational mechanics. As a member of the Computational Mechanics Laboratory at SUNY, Buffalo, Dr. Guin gained extensive experience in finite-element and boundary-element analyses for a wide range of engineering problems.
Tim Johnson Ph. D., Civil Engineering, Florida Institute of Technology	5	Dr. Johnson joined AIR in 2015 as an Engineer in AIR's Research Department. Prior to working with AIR, Dr. Johnson worked as a Vulnerability Modeler/Graduate Research Assistant for the Florida Public Hurricane Loss Model where he worked as the lead engineer in the vulnerability model team of the FPHLM. Dr. Johnson earned his Bachelors, Masters and Ph.D. in Civil Engineering from Florida Institute of Technology.
Cagdas Kafali Ph.D., Civil and Environmental Engineering, Cornell University	13	Dr. Cagdas Kafali is a Senior Vice President in AIR's Research and Modeling group, working primarily on wind vulnerability of civil engineering systems. He has been involved in the development of many of AIR's wind models, particularly the Asia-Pacific typhoon models and the European Extratropical Cyclone model, and more recently the U.S. and Canada wind storm models. Dr. Kafali holds an M.S. in Structural Engineering from Case Western Reserve University and a Ph.D. in Civil Engineering from Cornell University with a minor in Applied Mathematics. In his dissertation, he developed a probabilistic methodology for assessing performance of structural/nonstructural systems in a multi-hazard environment.
Karthik Ramanathan Ph.D., Civil and Environmental Engineering, Georgia Institute of Technology	8	Dr. Ramanathan is an Assistant Vice-President and Principal Engineer in AIR's Research and Modeling Department, working primarily on the wind and flood vulnerability of civil engineering systems. Dr. Ramanathan joined AIR in 2012 as an Engineer in our Research and Modeling Department. Prior to AIR, 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. Prior to joining

2.A.3. Vulnerability: **Name, Education**	**Years at AIR**	**Relevant Experience**
		Georgia Tech, Dr. Ramanathan obtained an M.S. from the University of Pittsburgh in Civil and Environmental Engineering with a special emphasis in Structural Engineering and Mechanics.
Kun Yang Ph.D., Civil and Environmental Engineering, University of Delaware	2	Dr. Yang joined AIR in 2018 and is an Engineer II in our Research Department. Prior to working with AIR, Dr. Yang worked as a Graduate Research Assistant for the University of Delaware, where he worked on an inter-disciplinary hurricane evacuation project that integrates meteorological and hydrological models, sociology prediction model, and transportation engineering model to support evacuation order decision making. Dr. Yang earned his B.E. in Automation with a focus on systems engineering from Huazhong University of Science and Technology, and his Ph.D. in Civil Engineering from the University of Delaware.

2.A.4. Actuarial Science: **Name, Education**	**Years at AIR**	**Relevant Experience**
Nicholas Brewer B.A., Actuarial Science, Bryant University	2	Mr. Brewer joined AIR in 2018 in the Consulting and Client Services Group as a Risk Analyst. He works on the Regulatory and Rating Agency team and primarily works on regulatory projects with departments of insurance. Previously he worked for Mercer as a Client Services Pensions Analyst. Before that, he worked for Allied World as an Actuarial Assistant. Mr. Brewer earned a B.A. in Actuarial Science from Bryant University.
Brendan Flaherty B.A., Mathematics, Stonehill College	2	Mr. Flaherty is a Manager in AIR's Consulting and Client Services Group. He works in the Regulatory and Rating Agency market segment assisting with various regulatory engagements and serving as primary liaison with the rating agencies. Previously, Mr. Flaherty worked for Mercer, as an actuarial consultant, specializing in long term financial forecasting and risk management strategies for U.S. pension plans. Mr. Flaherty earned a B.A. in mathematics from Stonehill College.
Stacey Gotham B.A., Mathematics, Rutgers College	12	Ms. Gotham is a Senior Actuary in the Consulting Services Group at AIR. She is a member of the American Academy of Actuaries AAA and a Fellow of the Casualty Actuarial Society FCAS. Also, she is also a member of the AAA's Property and Casualty Extreme Events and Property Lines Committee, and the Natural Catastrophe Subcommittee. Prior to joining AIR, Ms. Gotham was an actuary for the state of Massachusetts and held various actuarial positions with Liberty Mutual Insurance Group. She has a B.A. in Mathematics from Rutgers College.
Christy Shang M.S., Mathematics, University of Connecticut	9	Ms. Shang is a Manager in the Consulting and Client Services group at AIR. She works in the Regulatory and Rating Agency market segment, where she ensures compliance with all regulatory requirements of catastrophe models and assists clients in dealing with regulators and rating agencies. Ms. Shang holds a B.A. in Economics from Boston University and an M.S. in Mathematics from the University of Connecticut.

2.A.5. Computer/ Information Science: **Name, Education**	**Years at AIR**	**Relevant Experience**
Donald Alcombright B.S., Information Systems, Daniel Webster College	13	Mr. Alcombright is the Software Support Manager in AIR's Technical Services Group.

2.A.5. Computer/ Information Science: **Name, Education**	**Years at AIR**	**Relevant Experience**
Sikondrulu Alekhya B.E in Electronics and Communication, Vasavi college, Hyderabad, India	1	Ms. Alekhya took her first career step at AIR in June 2019 as Software Quality Assurance Engineer. She has received her bachelors degree in Electronics and Communication Engineering from Vasavi college of Engineering, Hyderabad. Her academic projects include Developing a Mobile Application called "College Diaries" for notifying students with the current happening in the college, Medication Reminder box and Mail Notification system using Bluetooth.
Vijay Santosh Alla M.S. Computer Science, New Horizon College of Engineering (Formerly National Institute of Management and Information Sciences, Bangalore University), India	1	Mr. Vijay Santosh is a Senior Manager in AIR's Quality Assurance Team and joined AIR in Jan 2020. He worked with Publicis Sapient for 9+ Years before joining AIR in Jan 2020. He has overall 16+ years of working experience with Products and Services clients. He and his team are responsible for on time delivery of Product and ensuring the delivery quality meets the set standards. He holds a master's degree in Computer Science and bachelor's degree in Statistics. He has good understanding of Data Science Architecture and currently pursuing a course for Data Science Architect.
Tejaswi Battula M.S., Computer Science Kansas State University	5	Ms.Tejaswi joined AIR in June 2015 as a Database Engineer in the Software Development Group and is now a Senior Database Engineer. She has completed a Bachelor of Technology in Computer Science from JNTU, India. Prior to joining AIR she worked as a Database Engineer at Merkle,Inc.
Abhinav Chintakindi B.E., Computer Science and Engineering, Vasavi College of Engineering(OU), Hyderabad, India	7	Mr. Abhinav Kumar took his first career step at AIR in July 2013 as Software Developer I into MIG team. Currently he is taking responsibilities as "Senior Software Engineer II" in the Model Implementation Group at AIR Hyderabad, working on implementing the Hurricane Model for the United States, as well as other AIR models, in Touchstone. He completed his Bachelors of Engineering degree in Computer Science and Engineering from Vasavi College of Engineering (OU), Hyderabad.
Dennis Costello B.S., Civil and Environmental Engineering, Cornell University	15	Mr. Costello joined AIR in 2005 and is a Senior Product Manager responsible for model implementation within the AIR's software products.
Igor Cizelj Ph.D., Mechanical Engineering, Boston University	6	Dr. Igor Cizelj is a Team Lead in the Core Quality Assurance Team. He joined AIR in 2014 as a Core Quality Assurance Associate in the Product Management group. At AIR, he has created tools and crafted workflows that allow efficient, traceable, and repeatable validation of catastrophe models in all phases of model development, implementation, and quality assurance. He has have worked on earthquake, tsunami, wildfire, flood, and wind catastrophe models. Before joining AIR, during his research years at Boston University, Dr. Cizelj has proposed and evaluated methods and algorithms for synthesizing control strategies for different robotic models from temporal logic specifications. Dr. Cizelj holds a Ph.D. in Systems Engineering from Boston University and an M.A. in Mechanical Engineering from University of Zagreb.

2.A.5. Computer/ Information Science: **Name, Education**	**Years at AIR**	**Relevant Experience**
Rohan Das MSc. Actuarial Science, ASIBAS – Amity University	4	Mr. Das is a Model QA Analyst II in AIR’s Model Quality team. AIR has been the first step for Mr. Das in his career. His current responsibilities include the validation of models implemented by MIG on Touchstone against the Research model and also independent validation of the model from Touchstone to ensure that the behavior of the model is on expected lines. Models validated in the past include U.S. Tropical Cyclone's Builder's Risk Module, Japan Tropical Cyclone, Japan Inland Flood, Europe Tropical Cyclone, Europe Severe thunderstorm, U.S. Inland Flood-TS8 update, U.S. Tropical Cyclone-TS8 and TS 2020.
Suryanarayana Datla M.E., Structural Dynamics, IIT, Roorkee, India	19	Mr. Datla joined AIR Hyderabad in February 2001 and is currently Vice President of Research and Director for the Model group in Hyderabad. Mr. Datla has more than 18 years of experience in developing catastrophe loss estimation models. His current responsibilities include implementation of catastrophic risk assessment models developed for various regions and perils worldwide into AIR products. He is also involved in development of catastrophe models for various regions/perils and manages the GIS and Flood Research teams in Hyderabad. Mr. Datla holds a M.E. (Masters in Engineering) in Structural Dynamics from IIT Roorkee, India. Prior to joining AIR, he was a senior engineer at RMS India Office at Delhi for three years, where he played a crucial role in the development of earthquake, tornado, and hurricane models. In addition, he conducted post-disaster surveys for Gujarat (1998) and Orissa (1999) cyclones.
Burcu Davidson M.S., Computer Science, Suffolk University, Boston.	21	Ms. Davidson is the Vice President of Software Development at AIR. She joined AIR in 1999. Previously, she worked as an engineer at Turkish Telecom in Ordu, Turkey.
Abhilash Dhadwai Bachelor of Technology, Electronics and Communication Engineering, SRM University, Chennai, India	0.5	Mr. Abhilash Joined AIR in 2020 as Senior Software Engineer I in the Software Development group. Before joining AIR, he has four years of experience in software development using C, C++ at L and T technology services as a Senior Engineer. He has completed his Bachelor of Technology in Electronics and communication from SRM university, Chennai.
Phaninath Dheram M.Phil, Computer Science Jawaharlal Nehru University, New Delhi	8	Mr. Dheram joined AIR in 2012 as Manager and is currently the Senior Manager of the Model Implementation Group in Hyderabad. For three years prior to coming to AIR, Mr. Dheram was an independent software development consultant. For nearly 11 years before that he worked for Mentor Graphics India Pvt Ltd. in Hyderabad, developing software tools for electronic circuits design.
Srimanta Ghosh Ph.D., Hydraulics and Water Resources Eng., I.I.T. Madras, Chennai, India	3	Dr. Ghosh works as Lead Engineer in the Model Quality team at AIR. He is responsible for validating the atmospheric catastrophe risk models. Prior to joining at AIR, he worked as a research scholar and earned Ph.D. in Hydraulics and Water Resources Engineering from Indian Institute of Technology Madras. His Ph.D. dissertation was on Frequency Estimation of Floods, Droughts, and Precipitation at Regional- and Local-scale, using state-of-the-art Statistical, Physical, and Geo-Spatial Models. He has published research articles in reputed peer-reviewed international journals and presented in conferences.

2.A.5. Computer/ Information Science: **Name, Education**	**Years at AIR**	**Relevant Experience**
Rohit Jain B.E. Computer Science, Medicaps Institute of Technology & Management, India	2	Mr. Jain is a Principal Database Engineer in Software Development Group. Prior to joining AIR, he has worked for Eze Software Group in the agile development environment on their financial trading platform. Prior to that he was working with Humana implementing business development solutions for provider team. He has Bachelor of Engineering degree from MITM, India.
Sai Teja Jenula Bachelor of Technology, Civil Engineering, CMRCET, JNT University, Hyderabad	2	Mr. Jenula took his first career step at AIR in May 2018 and is a Model QA Analyst II in the Model Quality Team. His work at AIR is dedicated towards validating the Atmospheric Peril Models and has contributed majorly on testing the US Hurricane, US Inland Flood models and in creating the MQA's Acceptance plans for build certification. Mr. Jenula has achieved the designation of Certified Extreme Event Modeler by completing the requirements of the AIR Institute Certified Extreme Event Modeler Program. He received his bachelor's degree in Civil Engineering from JNT Univerisity, Hyderabad, India.
Aditya Jinna MS., Computer Engineering, Wayne State University, Detroit, MI	20	Mr. Jinna is a Team Lead in AIR's Software Development team. He joined AIR in 2000 and worked extensively across various products at AIR. He has a bachelor's degree in Electronics and Instrumentation Engineering from Osmania University and master's degree in Computer Engineering from Wayne State University in Detroit, MI.
Mohan Kandulapati B.S., Technology & Computer Science, Jawahar Lal Nehru Technological University, India	4	Mr. Kandulapati is a member of AIR's Software Quality Assurance group and holds the title of SQA Engineer II. Mr. Kandulapati previously worked for Tech Mahindra Ltd for three years before joining AIR in 2016. He has a Bachelor's degree in Technology and Computer Science from Jawahar Lal Nehru Technological University in Hyderabad, India.
Karl Kieninger B.A., Economics, University of Virginia	6	Mr. Kieninger joined AIR in 2015 and is a Principal Database Engineer and Team Leadin our Software Development Department. Prior to working with AIR, Karl worked as a Senior Developer for eHana LLC where he participated in agile development of web-based electronic health record system. He also worked as a Senior SQL Developer for Alere Accountable Care Solutions where he developed TSQL and PL/SQL routines for HIPAA compliant HIX platform. Mr. Kieninger has earned his Bachelor of Arts degree from the University of Virginia.
Visweswara Kokkonda Bachelor of Technology, Electronics and Communication Engineering, JNTU, India.	9	Mr. Kokkonda joined AIR, Hyderabad office in July 2011 as a Database Engineer in the Software group and is now a Lead Engineer. He has completed a Bachelor of Technology in Electronics and Communication Engineering from JNTU. Also, Mr. Kokkonda completed an Executive MBA in Project Management and Leadership Management from National Institute of Business Management, Chennai. Prior to joining AIR, he worked at Primaccess Technologies Ltd as a Software Programmer for 4 years, developing Web Applications using ASP.Net, C#, Vb.Net, Ajax, Webservices, JavaScript, MSSQL Server, MySQL, and PostgreSQL. He is a Microsoft-certified SQL Server Developer, Microsoft-Certified C# Developer and Certified Professional Scrum Master.

2.A.5. Computer/ Information Science: **Name, Education**	**Years at AIR**	**Relevant Experience**
Siddhartha Kumar Arya Master of Technology (MTech), Computer Science & Management, Deakin University, Melbourne, Australia	0.5	Siddhartha Kumar Arya joins AIR as an Information Security Manager in our Information Security group. Previously, Mr. Arya worked for Verizon Wireless as a Senior Principal Security Architect. At Verizon he was responsible for Cybersecurity Innovations; data protection; Information Security Management System; Security Operations; Security Architecture & Engineering; Application Security, IAM, Security assessment & testing, and Security Risk management frameworks. Mr. Arya holds Many data security patents for an end to end data protection. He served as Chairperson for multi-organization executive leaders to layout future security product roadmap for Teradata, Hadoop, Oracle, cloud, and open-source 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.
Peter Lewis B.S., Business Administration, Northeastern University	21	Mr. Lewis is a Senior Vice President in the Information Technologies and Services group. He is responsible for developing and executing information technology initiatives in support of AIR's business operations. He also leads the Technical Support and Integration Solution teams, which are responsible for the maintenance and support of AIR's hosted and desktop applications in addition to custom integration with customer's systems. Peter is a Microsoft® Certified Professional specializing in systems support and database administration.
John Lu M.S., Electrical Engineering, University of Kentucky	7	Mr. Lu is the Senior Director of Software Quality Assurance (SQA) in the Product Management Department at AIR. He joined AIR 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.
Manoj Medarametla M.S., Software Systems, Birla Institute of Technology & Science, Pilani, India	12	Mr. Medarametla joined AIR in 2008 and is currently a Manager in the Software Development group at Hyderabad office. Mr. Medarametla is Certified Extreme Event Modeler and he holds an M.S. in Software Systems from Birla Institute of Technology & Science, Pilani, Rajasthan, India.
Ram Nagulpally M.S., Mechanical Engineering, University of Arizona	8	Mr. Nagulpally is Vice President and head of AIR’s Quality Assurance group. He joined AIR in 2012. Prior to joining AIR, Ram served as a Consulting Director of Quality Assurance and Support at Reveal Data Corporation, where he successfully built a team to support the rapid growth of an early-stage startup, and he also managed delivery of the first Unicode-compliant localization product. Prior to that, he was Director of Operations for Geomagic, Inc., where he rolled out multiple versions of 3D analysis and modeling software. Ram has spent over 30 years leading engineering analysis teams in software development, professional services, and quality assurance. He holds a B.E. in Mechanical Engineering from Osmania University and an M.S. in Mechanical Engineering (Structural Mechanics) from the University of Arizona.

2.A.5. Computer/ Information Science: **Name, Education**	**Years at AIR**	**Relevant Experience**
Anup Rajashekharan Nair MBA, Business Analytics from Alliance University, India	1	Mr. Nair is the Manager of Model Quality Assurance team and joined AIR during Dec 2019. He is holding Engineering Degree in Civil Engineering from Government Engineering College, Kerala. Prior joining to AIR, he worked with Chubb Insurance as Account Operation Manager and with RMS India as Project Lead.
Gayatri Natarajan B.S., Electronics and Communications Engineering, Madras University, India	14	Ms. Natarajan is Vice President in the Product Management department at AIR. As Product Manager for Touchstone she manages product releases, leads the scoping and requirements for the implementation of models, analytics and hazard layers, and coordinates development activities and delivery of software products to completion. Ms. Natarajan also leads other Touchstone enhancements such as the introduction of loss modification capabilities and comparative analytics, open platforms, transparency and other key initiatives. Ms. Natarajan received her B.S. in Electronics and Communications Engineering from Madras University in India and was awarded the silver medal for top rank in her university.
Robert Newbold M.S., Information Systems, M.B.A Boston University	18	Mr. Newbold is Executive Vice President of Business Development, Marketing, and Client Services. He is responsible for the Americas and Bermuda business development team, the global marketing team, and for providing support and client service to AIR clients in the insurance, reinsurance, securitization, and intermediary markets in the Americas and Bermuda. Rob has been involved in a wide range of consulting engagements at AIR, including loss analyses, portfolio optimizations, economic impact analyses, and the management of more than 125 catastrophe bonds. Early in his career, he coordinated all facets of catastrophe modeling for one of the largest property and casualty insurers in the industry. Mr. Newbold received an M.B.A. and an M.S. in Information Systems from Boston University's Graduate School of Management. He received a B.S. in Systems Engineering from the University of Virginia. He has achieved the designation of Certified Extreme Event Modeler by completing the requirements of the AIR Institute Certified Extreme Event Modeler Program.
Martin Partyka B.S., Economics, Boston College	2	Mr. Partyka is a Manager of Internal Audit in AIR's Research team. Currently he is responsible for reviewing required documentation, standards and files developed during each phase of the model development. Prior to joining AIR, he has worked in the Internal Audit department in various industries such as banking, healthcare and insurance.
Sudhir Kumar Potharaju B.S., Electronics and Communications, Osmania University	19	Mr. Potharaju is a Senior Vice President at AIR. He is responsible for the Software Development, Product Management, and Quality Assurance teams, providing strategic execution of AIR's product and technology roadmap, and providing overall vision and direction to these groups. Mr. Potharaju has over 15 years of experience in developing software solutions. Prior to joining AIR, Mr. Potharaju worked at the Electronics Corporation of India Ltd. (ECIL) where he led various projects in the corporate R&D and Telecommunications groups. He earned a Bachelor's degree in Electronics and Telecommunications from and an Advanced Degree in Computer Applications, specializing in performance and scalability.

2.A.5. Computer/ Information Science: **Name, Education**	**Years at AIR**	**Relevant Experience**
Asha Prabhu B.Tech, Computer Science and Information Technology, VNR VJIET (Affiliated to JNT University), Hyderabad	8	Ms. Prabhu joined AIR in May 2011 and is a Senior Software Engineer III in AIR's Model team. Prior to joining AIR, she had four years of experience in software development/ enhancement using Microsoft Visual C++ (MFC) and SQL.
Andrew Rahedi M.A., Physics, Wesleyan University	13	Mr. Rahedi is the Director of the Core Quality Assurance Team. He joined AIR in 2008 as a Core Quality Assurance Associate in the Product Management group. Previously he was with the Hartford Life Insurance Company, where he worked as a Statistical Modeler. Andrew holds an M.A. in Physics from Wesleyan University.
Barbara Rosenstroch M.Engr, Nuclear Engineering and Applied Physics, Cornell University	8	Ms. Rosenstroch is a Principal Technical Writer in the Product Management Group. She is responsible for the development and maintenance of the Computer/Information Standards documentation for the Florida Commission on Hurricane Loss Projection Methodology process. In addition, she is in charge of the Using the Model in Touchstone series of documents, as well as the model documentation for the AIR Hurricane Model of the United States, AIR Hurricane Model for Offshore Assets, AIR China Typhoon Model, AIR Japan Typhoon Model, and the Model Builder documentation. She joined AIR in January 2012. Before joining AIR, she worked as a Senior Technical Writer at Nokia Inc. in Burlington, MA where she managed and created content for the Web Developer's Library. Also at Nokia, she held the position of Senior UI Designer, designing new features for mobile phone applications software. Ms. Rosenstroch earned a Master of Engineering degree in Nuclear Engineering and Applied Physics from Cornell University and a Bachelor of Science degree in Nuclear Engineering from Columbia University. She had a 20- year career as a nuclear engineer, performing radiation protection and shielding analyses for nuclear power plants, as well as leading projects in spent fuel storage, radioactive waste disposal, and decontamination and decommissioning and authoring consulting studies for clients.
Indumathi Sagyari B. Tech, Computer Science, JNT University, Hyderabad	13	Ms. Indumathi Sagyari is a Team Lead Engineer working in the Model Implementation Group. She joined AIR's Hyderabad Office in January 2008 as a Senior Software Engineer. Prior to joining AIR, 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 etc., her academic projects include Video Conferencing, Messaging Service etc., using Java technologies.

2.A.5. Computer/ Information Science: **Name, Education**	**Years at AIR**	**Relevant Experience**
Praveen Sandri Ph.D., Civil Engineering, Texas Tech University	23	Dr. Sandri is the Executive VP and the Managing Director of AIR's office in Hyderabad, India. He is responsible for the strategic management of the Indian Operations which provides services in the areas of software development, model implementation, GIS, model and product testing, analytics and data services along with providing client services and business development initiatives in India and the Middle East regions. He has more than 20 years of experience in probabilistic risk analysis for natural and man-made catastrophes and has been instrumental in the development of various catastrophe models worldwide. At AIR, he specialized in structural and wind engineering aspects of the AIR hurricane modeling technology. Prior to joining AIR, Dr. Sandri was a research associate at the Wind Engineering Research Center of Texas Tech University where he worked in wind engineering and was the Manager of the Wind Engineering Research Field Laboratory (WERFL). He applied expert systems and artificial neural networks to wind engineering applications. He was the project leader for the development of WIND-RITE™, a knowledge-based expert system for the Insurance Institute for Property Loss Reduction, and he developed the "Expert System as an Alternate Code Compliance Methodology" for the Florida Housing Finance Agency.
Scott Sperling B.A., Economics, Boston University	8	Mr. Sperling joined AIR in 2012 as a Core QA Associate in the Product Management department. 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.
Apoorv Srivastav MBA, Birla Institute of Management and Technology, Noida, India	6	Mr. Srivastav joined AIR in Jan 2014 as Risk Analyst 1 in the Model Quality Assurance Group and is now a Sr. Model QA Analyst II. He has completed his bachelors from Commerce from Lucknow Christian College, Lucknow, India. He has also completed his Master of Business Administration from Birla Institute of Management and Technology, Greater Noida, India- with a specialization in Insurance Business Management Domain. During his 6+ Years career is AIR he has gained knowledge on all the Different Models & perils supported by AIR & also has good experience in working on Custom Projects.
Ashwin Kasilingam Thillai Natarajan M.S., Industrial Engineering, Northeastern University	5	Mr. Thillai Natarajan joined AIR in 2015 and is a Core QA Associate III in the Core Quality Assurance Team. He is responsible for validating the vulnerability module of atmospheric peril models. Prior to joining AIR, Mr.Thillai Natarajan worked as Data science Intern at New England Bio Labs, Ipswich MA. Prior to that he worked as Quality Assurance associate at MAHLE IPL Ltd., Chennai, India. He holds a master's degree in Industrial Engineering from Northeastern University, Boston and a Bachelors in Engineering in Mechanical Engineering from Anna University, India.
Srinivas Thoudoju Bachelor of Technology, SRTIST, Nalgonda	11	Mr. Thoudoju is a Lead Engineer in the Software Development Group in AIR's Hyderabad office. Prior to joining AIR, he worked as a Release Engineer for Broadridge Financial Solutions.
Ramesh Ummati M.S., Earthquake Engineering, Indian Institute of Technology, Roorkee	14	Mr. Ummati is a Senior Principal Engineer in the Model QA group at AIR Hyderabad. He plays a lead role in all aspects of testing the 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 AIR, Mr. Ummati worked as an Assistant Executive Engineer in Panchayat Raj (Government Organization) Engineering Department.

2.A.5. Computer/ Information Science: **Name, Education**	**Years at AIR**	**Relevant Experience**
Satish Vootukuru M.S. in Information Technology (MSIT), International Institute of Information Technology (IIIT), Hyderabad	5	Mr. Vootukuru is a Senior Software Engineer I in the Model Implementation Group at AIR Hyderabad, working on implementing the Hurricane Model for the United States, as well as other AIR models, in Touchstone. Prior to joining AIR, 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.
Yingqun Wang M.S., Computer Science, California State University	13	Ms. Wang joined AIR in 2007 and is a Director in the Software Development group. She now is a team lead within the Touchstone Software Development group. She previously worked as a Programmer Analyst at the University of California. Ms. Wang holds an M.S. in Computer Science from California State University in San Bernardino, CA.
David Wilson MBA., Wallace E. Carroll Graduate School of Management, Boston College	17	Mr. Wilson is a Director in the Product Management group at AIR. He manages various feature enhancements for AIR catastrophe risk products, including various workflow enhancements, geocoding enhancements, updates to the supported administrative and postal boundary data, and updates to property-specific databases. He also manages various third-party licensing activities for the PM group. Prior to joining AIR in 2003, Mr. Wilson worked as a Product Manager at Vality Technology (now part of IBM) as a Product Manager for data quality and geocoding products. He received his B.Sc. degree in Mathematics from the State University of New York at Albany, and his MBA. from the Wallace E. Carroll Graduate School of Management at Boston College.

2.A.6. Data Management and Exposures: **Name, Education**	**Years at AIR**	**Relevant Experience**
Anthony Hanson M.A., Economics, Boston College	15	Anthony Hanson is a Director of Analytics in the AIR Exposures group where he assists in the development of AIR's global industry exposure. Some past projects include, modeling the value of Canadian infrastructure (transportation, utilities and communications), modeling the value of industrial facilities (manufacturing, mining and energy) for the industry exposure, and most recently researching global demand surge and its impact on losses. He earned his B.A., summa cum laude, in Economics from the University of Massachusetts and an M.A. in Economics from Boston College.
Cheryl Hayes M.A., Environmental Studies, Boston University	20	Ms. Hayes is a Vice President and manager of the Exposures, Data Management, Audit and Operation teams in the Research and Modeling Group. During her tenure at AIR, she has led a multi-disciplinary team in the development of comprehensive, high resolution industry exposure databases for more than 100 countries worldwide. She has also been instrumental in streamlining the development process for the industry exposure databases, and has worked to advance the quality of the industry exposures. In addition, she has been involved in numerous consulting and special projects, including catastrophe bonds and the FEMA Flood Insurance Risk Study. Prior to joining AIR, Cheryl 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.

2.A.6. Data Management and Exposures: **Name, Education**	**Years at AIR**	**Relevant Experience**
Aaron Knox B.S., Computer Science and Economics, Rose-Hulman Institute of Technology	1	Mr. Knox joined AIR in 2019 a Senior Analyst I in the Data Management Group. His primary focus has been to streamline our AIRFlow automatic data downloads 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 AIR, 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 the Rose-Hulman Institute of Technology.
Katherine Landesman M.S., Geographic Information Sciences, Clark University	3	Ms. Landesman joined AIR in 2017 and is a Senior Analyst I in the Data Management Group. Since working at AIR, she has been instrumental in creating on-demand maps for AIR's ALERT postings, coordinating and standardizing data storage and documentation processes between departments, and scripting AIRFlow real-time data downloads. Prior to joining AIR, she worked on earning both her B.A. in Global Environmental Studies and her M.S in Geographic Information Science from Clark University.

2.A.7. Editorial: **Name, Education**	**Years at AIR**	**Relevant Experience**
Heidi H. Carrell B.A. English (Hons.) University of New Hampshire	3	Ms. Carrell is a Senior Writer in AIR's Marketing Communications. She is a communications professional with over 15 years of writing, editing, publications management, and research support, including coordinating research grant applications. Prior to joining AIR, she was Communications Manager at Harvard's Joint Center for Housing Studies, where she managed the State of the Nation's Housing and other research publications. Before that, she was Lab Coordinator for the E.J. Safra Center for Ethics, an interdisciplinary research center at Harvard Law School, where she edited the working paper series and managed over 300 applications yearly for U.S. and international professional fellowships.

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

The following new employees have worked on the model or acceptability process since the previous submission. See Table 2. Professional Credentials (G-2. A.1-5) above for these individuals' bios. (Note that a "new" employee is new to the model development, to the acceptability process, or to both):

Jeff Strong	Igor Cizelj	Anup Rajashekharan Nair
Yang Kun	Rohan Das	Martin Partyka
Brendan Flaherty	Abhilash Dhadwai	Asha Prabhu
Sikondrulu Alekhya	Rohit Jain	Apoorv Srivastav
Vijay Santosh Alla	Sai Teja Jenula	Ashwin Kasilingam Thillai Natarajan
Tejaswi Battula	Siddhartha Kumar Arya	Aaron Knox
Abhinav Chintakindi	Peter Lewis	Boyko Dodov
Dennis Costello	Manoj Medarametla	Phillip Jue
Heidi Carrell		Ying Zhou

The consultants listed below have worked on the acceptability process:

- Dr. Carol Friedland, Ph.D., P.E., C.F.M.
- Narges Pourghasemi

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

The AIR Hurricane Model for the U.S. Workflow is illustrated in Figure 8.

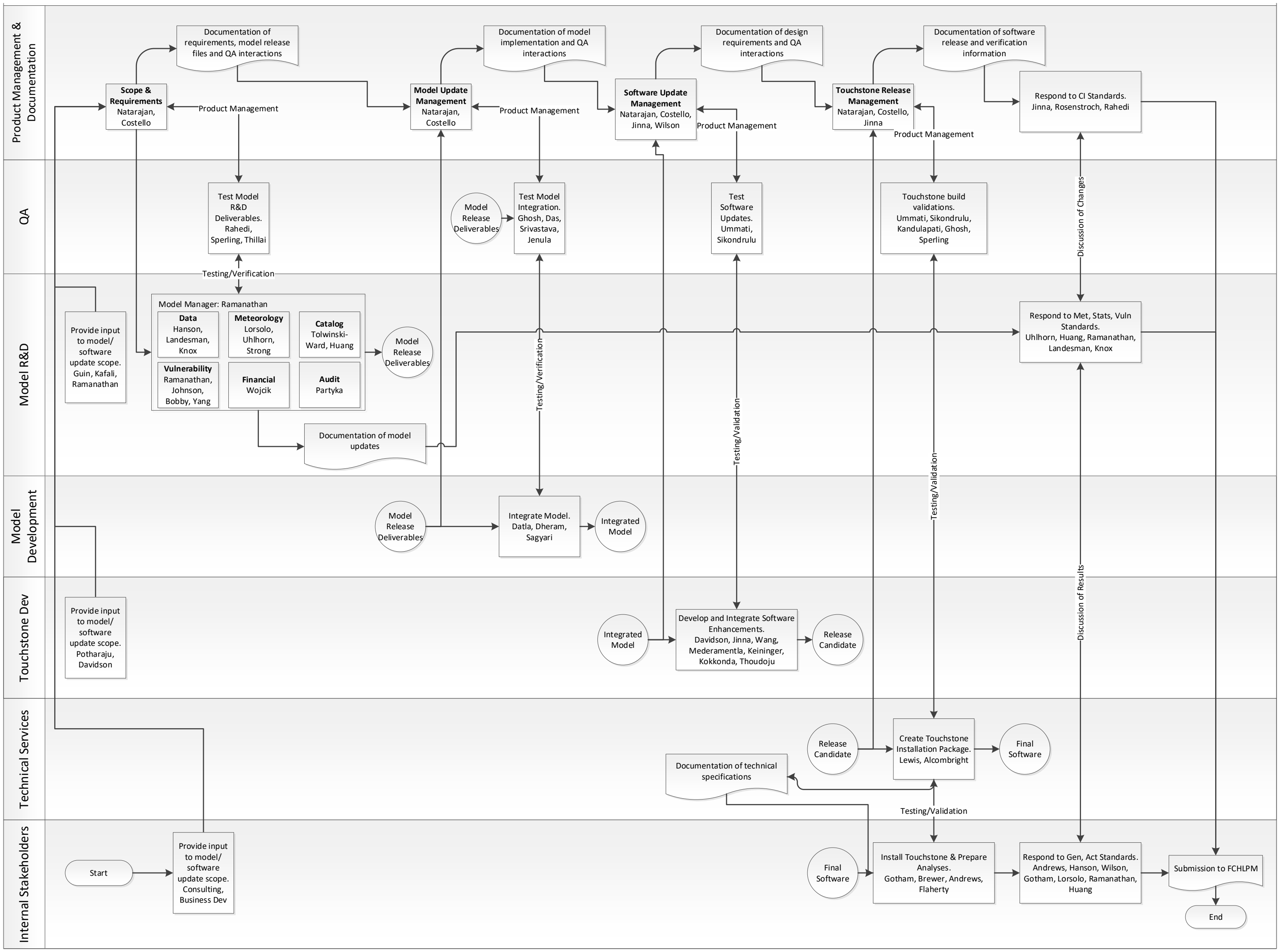


Figure 8. AIR Hurricane Model for the U.S. Workflow

Peer Reviewers

3. Independent Peer Review

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, and 2020.

4. Actuarial Science

Reviewed by John W. Rollins, FCAS, MAAA, in both 2010 and 2012.

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.

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 CV is included in Appendix 7. Her report is included in Appendix 8.

Narges Pourghasemi's CV is included in Appendix 7. Her report is included in Appendix 8.

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.

AIR has no on-going functional relationship with any of the persons who performed independent reviews, nor with any of their employees or consultants, nor with any independent organization.

Certification Links

4. Provide a completed Form G-1, General Standards Expert Certification. Provide a link to the location of the form.

Link: Form G-1: General Standards Expert Certification

5. Provide a completed Form G-2, Meteorological Standards Expert Certification. Provide a link to the location of the form.

Link: Form G-2: Meteorological Standards Expert Certification

6. Provide a completed Form G-3, Statistical Standards Expert Certification. Provide a link to the location of the form.

Link: Form G-3: Statistical Standards Expert Certification

7. Provide a completed Form G-4, Vulnerability Standards Expert Certification. Provide a link to the location of the form.

Link: Form G-4: Vulnerability Standards Expert Certification

8. Provide a completed Form G-5, Actuarial Standards Expert Certification. Provide a link to the location of the form.

Link: Form G-5: Actuarial Standards Certification

9. Provide a completed Form G-6, Computer/Information Standards Expert Certification. Provide a link to the location of the form.

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

Standard G-3: Insured Exposure Location

Relevant Form:

- G-1, General Standards Expert Certification

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, 2020, which is less than 24 months before the upcoming submission date of November 1, 2020. This information originates from the United States Postal Service (USPS).

Disclosure 1 describes the source of the ZIP Code data and AIR'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 Pro Team.

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

The AIR Hurricane Model for the U.S. uses population-weighted ZIP Code centroids. Disclosure 5 gives a description of ZIP Code centroid data received from the vendor and the process AIR follows to validate the population weighting. That process and resulting ZIP-related databases are trade secret and will be reviewed with the Pro Team.

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

AIR purchases its ZIP Code information from a vendor and verifies it for accuracy and appropriateness. The methodology employed by AIR'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 AIR 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 Disclosure 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 Pro Team.

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.

Disclosure 5 describes the processes AIR 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 Pro Team.

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.

Disclosure 3 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 Pro Team.

Disclosures

1. 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.

Zip Code Data and Methods

The current ZIP Code database is referred to as ZipAll2020_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.

ZIPAll2020_Output is compiled from data sets obtained from third party vendors. Data obtained from Environics 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 2020 was used as the most current ZIP list available prior to software finalization. This data was obtained in April 2020 from a third-party vendor, ZIPInfo, with an effective date of April 1, 2020. The product name is ZIPList5Max.

2. 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 AIR's master database of ZIP Codes for all years from 1990 through 2020. 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 AIR'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.

3. Describe the data, methods, and process used in the hurricane model to convert among street addresses, geocode locations (latitude-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 Touchtone 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.

4. ***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 AIR has found to exist in the past years to the current list of modellable 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.

5. 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 Environics, and mapping all other known ZIP Codes to those bounded ZIP Codes if they are not provided in Environics' 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 Environics 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

Relevant Form:

- *G-1, General Standards Expert Certification*

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

All components of the AIR Hurricane Model for the U.S. 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 Pro 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

Relevant Forms (included in Appendix 1)

- *Form G-1 General Standards Expert Certification*
- *Form G-2 Meteorological Standards Expert Certification*
- *Form G-3 Statistical Standards Expert Certification*
- *Form G-4 Vulnerability Standards Expert Certification*
- *Form G-5 Actuarial Standards Expert Certification*
- *Form G-6 Computer/Information Standards Expert Certification*
- *Form G-7 Editorial Review Expert Certification*

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

All sections of this submission have been reviewed and edited for grammatical correctness, typographical accuracy, and completeness by a Principal Technical Writer from AIR's software and model documentation 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, 2019, and understood the submission requirements prior to working on AIR's submission.

Disclosures

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 Editor maintains the submission in the primary document repository for the Florida Commission project in the Microsoft Team created for this project. Teams integrates Microsoft's SharePoint file management with communication and tracking features in a secure intranet environment that facilitates collaboration.

The Editor distributes the individual standards with tracked changes turned on to the subject matter experts (SME) for the respective Report of Activities (ROA) standards via folders in the dedicated "channels" in the Florida Commission Team. The SMEs review and update their respective responses to all ROA standards using Microsoft Word, checking the files in and out of Teams and using the tracked changes feature to keep track of everything they changed. SharePoint provides a range of version control features, and the version history can be retrieved at any time to show what changed in any given version.

The Editor is the only person who incorporates the SMEs' comments into the final document, which is maintained in a separate Teams channel with secure permissions settings. The Editor reviews all changes before incorporating them in the master submission document. This channel's communication thread is also used to share best practices and submission information.

The Editor creates a pdf file from the updated submission Word file, which is reviewed internally before it is sent for final printing. All personnel who edited the Submission must sign off on the final submission pdf to verify that the content accurately reflects their edits. The Editor also reviews the printer's proof of the final submission to ensure fidelity to the master document file.

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 set 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.

3. ***Provide a completed Form G-7, Editorial Review Expert Certification. Provide a link to the location of the form.***

Link: Form G-7: Editorial Review Expert Certification

Meteorological Standards

Standard M-1: Base Hurricane Storm Set

Relevant Forms:

- *G-2, Meteorological Standards Expert Certification*
- *M-1, Annual Occurrence Rates*
- *A-2, Base Hurricane Storm Set Statewide Hurricane Losses*
- *S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year*
- *S-5, Average Annual Zero Deductible Statewide Hurricane Loss Costs – Historical versus Modeled*

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

Model calibration and validation of storm parameters, including annual frequency, make use of the National Hurricane Center’s (NHC) latest version of HURDAT2, incorporating the period 1900–2018 and valid as of July 1, 2019

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

No temporal trending, weighting or partitioning was applied to the Base Hurricane Storm Set. Calibration and validation are based on the complete historical set starting in 1900. (see Disclosure 1)

Disclosures

1. Specify the Base Hurricane Storm Set release date and the time period used to develop and implement landfall and by-passing hurricane frequencies into the hurricane model.

The Base Hurricane Storm 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 July 1, 2019, and spans the years 1900–2018.

2. *If the modeling organization has made any modifications to the Base Hurricane Storm Set related to hurricane landfall frequency and characteristics, provide justification for such modifications.*

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 AIR model computes both local intensities and damages using an hourly timestep, and so AIR derives hourly-resolution tracks from the raw HURDAT before using it for modeling activities. For each storm, landfall is defined with respect to intersection of the piecewise linear representations of both the track and the model coastline (see Standard M-2, Disclosure 9). Statistical distributions for annual landfall frequency, spatial location of landfalls, and landfalling central pressure (the metric of intensity used to drive the model for local winds) are derived from these modifications of the data.

3. *If the hurricane model incorporates short-term, long-term, or other systematic modification of the historical data leading to differences between modeled climatology and that in the Base Hurricane Storm Set, describe how this is incorporated.*

The model does not incorporate any short-term or long-term modifications to the historical data. The modeled climatology is based on the entire Base Hurricane Storm Set consisting of known characteristics from 1900 through 2018.

4. *Provide a completed Form M-1, Annual Occurrence Rates. Provide a link to the location of the form.*

Link: Form M-1: Annual Occurrence Rates

M-2 Hurricane Parameters and Characteristics

Relevant Forms:

- *G-2, Meteorological Standards Expert Certification*
- *S-3, Distributions of Stochastic Hurricane Parameters*

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

Methods for depicting all modeled hurricane characteristics 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 HURDAT-2 Base Hurricane Storm Set contains much of the information in the literature (e.g., track, intensity, etc.) 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 et al., 1979
    - 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., 2015
- Gradient wind reduction
    - Franklin et al., 2003
    - Powell et al., 2009

Disclosures

1. Identify the hurricane parameters (e.g., central pressure, radius of maximum winds) 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

2. Describe the dependencies among variables 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 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, 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, following 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 Hurricane Parameters and Characteristics, Disclosure 3). 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), and a maritime adjustment (derived from the research of Powell et al., 2003) which is dependent on the windspeed.

3. *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 Standard S-1, Disclosure 1.

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 lognormal 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 placed, based on geographical constraints. The distributions used are mixtures of Normal distributions bounded based on geography and the historical record.

Gradient Wind Reduction Factor (GWRF)

The model uses a stochastic 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/Hurricane Research Division in Miami, Florida), as well as results from published literature (Franklin et al. 2003, Powell et al. 2009). As described in Standard M-2, Disclosure 2, for a given storm, 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 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 Standard M-2, Disclosure 10.)

4. *Describe if and how any hurricane parameters are treated differently in the historical and stochastic storm sets and provide rationale.*

Hurricane parameters are treated identically in the historical 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, Disclosure 3.

5. ***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 vortex winds to surface winds including the treatment of the inherent uncertainties in the conversion factor with respect to location of the site compared to the radius of maximum winds over time. Justify the variation in the surface winds conversion factor 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 Standard M-2, Disclosure 3, represents a model parameter which varies stochastically by storm, and varies by location as a function of the PWF and distance from Rmax. The Radial Adjustment Function (RAF) adjusts the GWRF as a function of distance to the eyewall (r) 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/Hurricane Research Division 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.

6. ***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 1-minute sustained wind, thus there is no need to convert winds to (3-second) gusts. Conversion of 10-minute averaged wind speeds to 1-minute sustained winds is based on accepted engineering relationships (Simiu and Scanlan, 1996, N. Cook, 1985, and ESDU Engineering Sciences Data, 1994). The conversion factor varies from 1.12 to 1.26, depending on the land use/land cover distribution about a location.

7. ***Describe the historical data used as the basis for the hurricane model hurricane tracks. Discuss the appropriateness of the hurricane model stochastic hurricane tracks with reference to the historical hurricane data.***

The HURDAT2 database provides data at synoptic times, with the inclusion of data at non-synoptic times for critical events of a storm lifetime (time of landfall, maximum intensity, etc.). The dataset allows for a resolution that is sufficient to capture the evolution of each storm across the Atlantic basin. The inclusion of the landfall point for reanalyzed storms as well as recent storms provides the model the necessary information to appropriately change the storm characteristics once it moves inland. In the case of storms that have not yet been reanalyzed, the model uses detailed landfall information available in Appendix A in NOAA Technical Memorandum NWS NHC-6, Tropical Cyclone Reports from NHC (available at http://www.nhc.noaa.gov/pastall.shtml), peer-reviewed publications, UNISYS, Extended Best Track Dataset, and NOAA Technical Reports NWS-23 (Schwerdt et al., 1979) and NWS-38 to generate storm characteristics at landfall.

The analysis of the data shows that first-order Markov models are appropriate for track direction and forward speed. Higher order dependence present in the central pressure along the track is represented using a second-order autoregressive time series model. The parameters of these models are estimated using a procedure that captures the spatial variability in the behavior of the storms in different parts of the Atlantic basin.

The landfall information, including locational frequency and storm intensity, is also used to eliminate tropical storm landfalls and generate post-landfall hurricane tracks. The Atlantic basin-wide tracks are integrated with the post-landfall hurricane tracks using a spline smoothing technique that ensures consistency in intensity, radius of maximum winds and storm heading across the tracks. The methodology produces realistic tracks that resemble the full range of diverse storm tracks that have been observed historically across the Atlantic basin and the U.S. mainland.

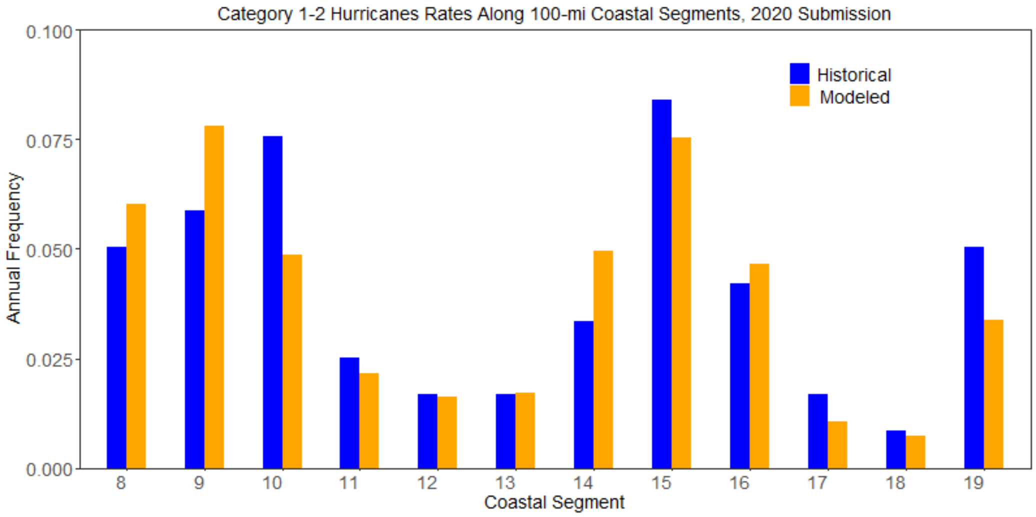
8. ***If the historical data are partitioned or modified, describe how the hurricane parameters are affected.***

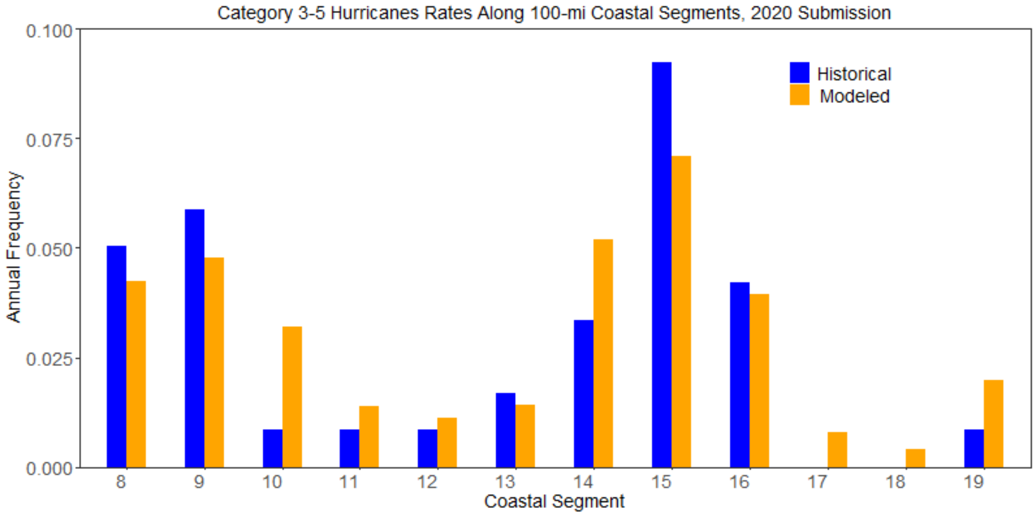
The data have not been temporally partitioned, but for the purpose of parameter estimation the data are grouped by coastal segment, as described in Standard M-2, Disclosure 9 below.

9. ***Describe how the coastline is segmented (or partitioned) in determining the parameters for hurricane annual landfall occurrence rates used in the hurricane model. Provide plots of the annual landfall occurrence rates obtained directly from the Base Hurricane Storm Set for two intensity bands (Saffir-Simpson categories 1-2 and 3-5) as functions of coastal segments along Florida and adjacent states. Plot on the same axes the modeled annual landfall occurrence rates over the Base Hurricane Storm Set period. If the modeling organization has a previously-accepted hurricane model, also plot on these axes the previously-accepted hurricane model annual landfall occurrence 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 the following figure.


Category 1-2 Hurricanes Rates Along 100-mi Coastal Segments, 2020 Submission
Annual Frequency
0.100
0.075
0.050
0.025
0.000
Historical
Modeled
8
9
10
11
12
13
14
15
16
17
18
19
Coastal Segment


Category 3-5 Hurricanes Rates Along 100-mi Coastal Segments, 2020 Submission
Annual Frequency
0.100
0.075
0.050
0.025
0.000
Historical
Modeled
8
9
10
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12
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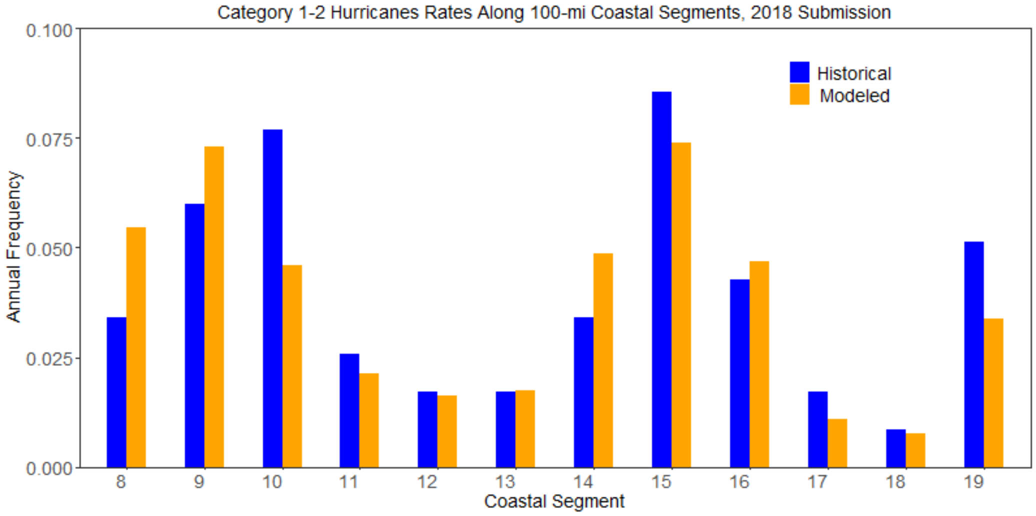
14
15
16
17
18
19
Coastal Segment


Category 1-2 Hurricanes Rates Along 100-mi Coastal Segments, 2018 Submission
Annual Frequency
0.100
0.075
0.050
0.025
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Historical
Modeled
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Coastal Segment

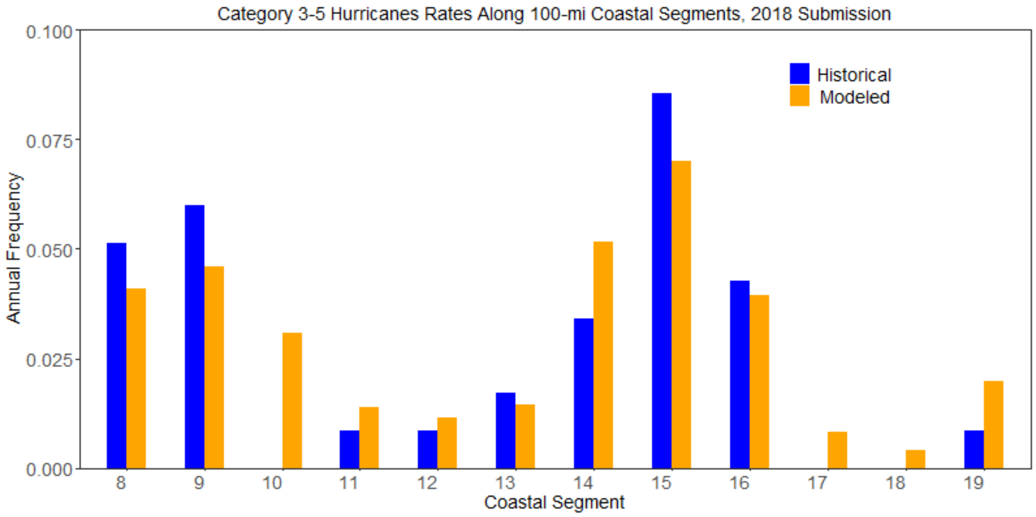


Figure 9. Annual Hurricane Landfall Frequency by Coastal Segment, Historical vs. Modeled, 1900-2018

10. 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).

Standard M-3: Hurricane Probability Distributions

Relevant Forms

- G-2, Meteorological Standards Expert Certification
- M-1, Annual Occurrence Rates
- A-2, Base Hurricane Storm Set Statewide Hurricane Losses
- S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year
- S-3, Distributions of Stochastic Hurricane Parameters

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

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 historical hurricanes in the Atlantic basin 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 0.61 landfalling hurricanes per year agrees with the average annual historical frequency of 0.61 landfalling hurricanes per year.

Hurricane intensity 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 Standard S-1, Disclosure 1.

Forward speed is modeled using a Lognormal distribution. The average simulated forward speed for landfalling hurricanes in the region is 13.8 mph and the average forward speed calculated from hurricanes occurring between 1900 and 2018 is 13.8 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 HURDAT data. The fitted Normal distribution is consistent with that described in the paper. The mean of both the modeled distribution and 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.

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

As shown in Figure 9 in Standard M-2, the modeled hurricane probabilities for categories 1-2 and 3-5 hurricanes accurately represent the historical record through 2018, 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.

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

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

The model uses maximum 1-minute sustained 10-meter windspeed when defining hurricane landfall intensity for both the Base Hurricane Storm Set and the modeled windspeeds. The Saffir-Simpson Wind Scale is used to determine the values in Form M-1.

Disclosures

1. Provide a complete list of the assumptions used in creating the hurricane characteristics databases.

No assumptions are made in developing these databases.

2. Provide a brief rationale for the probability distributions used for all hurricane parameters and characteristics.

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 and in Standard M-1. The choice of modeled distribution and goodness-of-fit is disclosed in detail in Standard S-1.

Standard M-4: Hurricane Windfield Structure

Relevant Forms:

- *G-2, Meteorological Standards Expert Certification*
- *M-2, Maps of Maximum Winds*
- *A-2, Base Hurricane Storm Set Statewide Hurricane Losses*

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

The AIR hurricane model wind field is modeled parametrically, based on the formulation of Willoughby et al. (2006). Modeled winds are derived from observations in 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.

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

The National Land Cover Database (NLCD) 2011 is used in the AIR Hurricane Model. No further justification is required.

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 2011 (NLCD 2011) data as published in 2014 (Homer, et al., 2012, Jin, et al., 2013). 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).

D. With respect to multi-story buildings, the hurricane model windfield shall account for the effects of the vertical variation of winds if not accounted for in the vulnerability functions.

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

1. ***Provide a rotational windspeed (y-axis) versus radius (x-axis) plot of the average or default symmetric wind profile used in the hurricane model and justify the choice of this wind profile. If the windfield represents a modification from the previously-accepted hurricane model, plot the old and new profiles on the same figure using consistent inputs. Describe variations between the old and new profiles with references to historical storms.***

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. The following figure shows the wind profile for an average Florida storm.

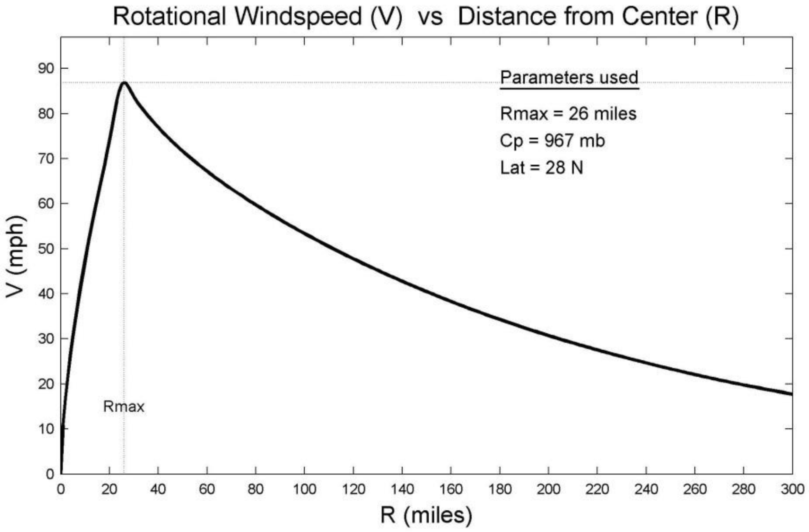


Figure 10. Symmetric Gradient Wind Profile (Assuming Updated Florida Mean Values of Rmax, Cp and Latitude)

2. ***Describe how the vertical variation of winds is accounted for in the hurricane model where applicable. Document and justify any difference in the methodology for treating historical and stochastic storm sets.***

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 under Standard M-4.A 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. There are no differences in the treatment of historical and stochastic storms.

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

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

4. *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.

5. *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 2011 (NLCD 2011) 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. LULC database.

6. *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 2011 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 upstream radius 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 (ESDU Engineering Sciences Data, 1994).

To define ZIP Code level properties, the values within a radius of 5-km of the population-based ZIP Code centroid are averaged. This particular averaging radius was used to approximate the mean area for modeled ZIP Codes, 75 km^2, as determined via GIS analysis.

7. *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.*

The following figures 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.

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.

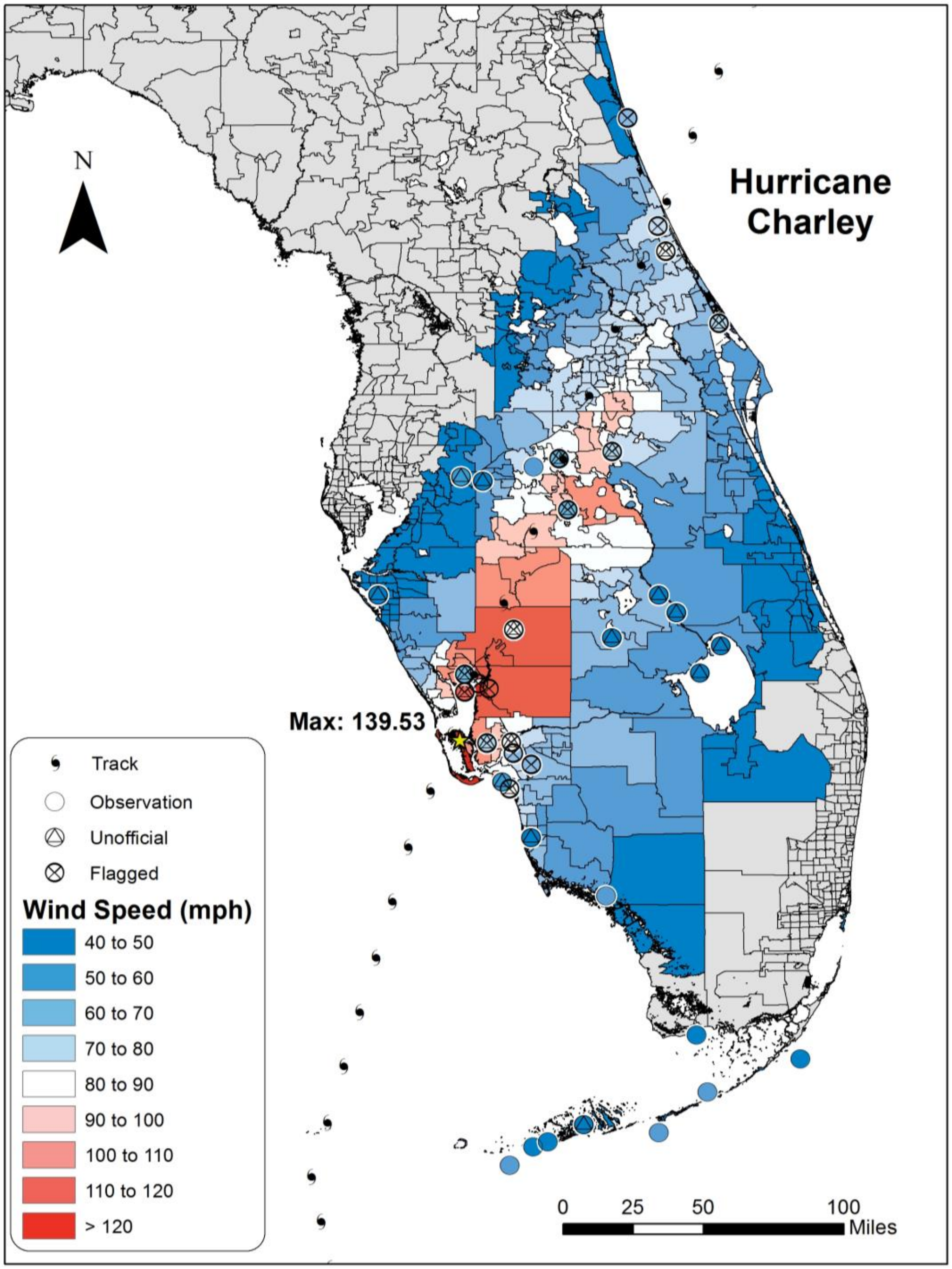


Figure 11. Observed and Modeled Wind Speeds, Hurricane Charley (2004)

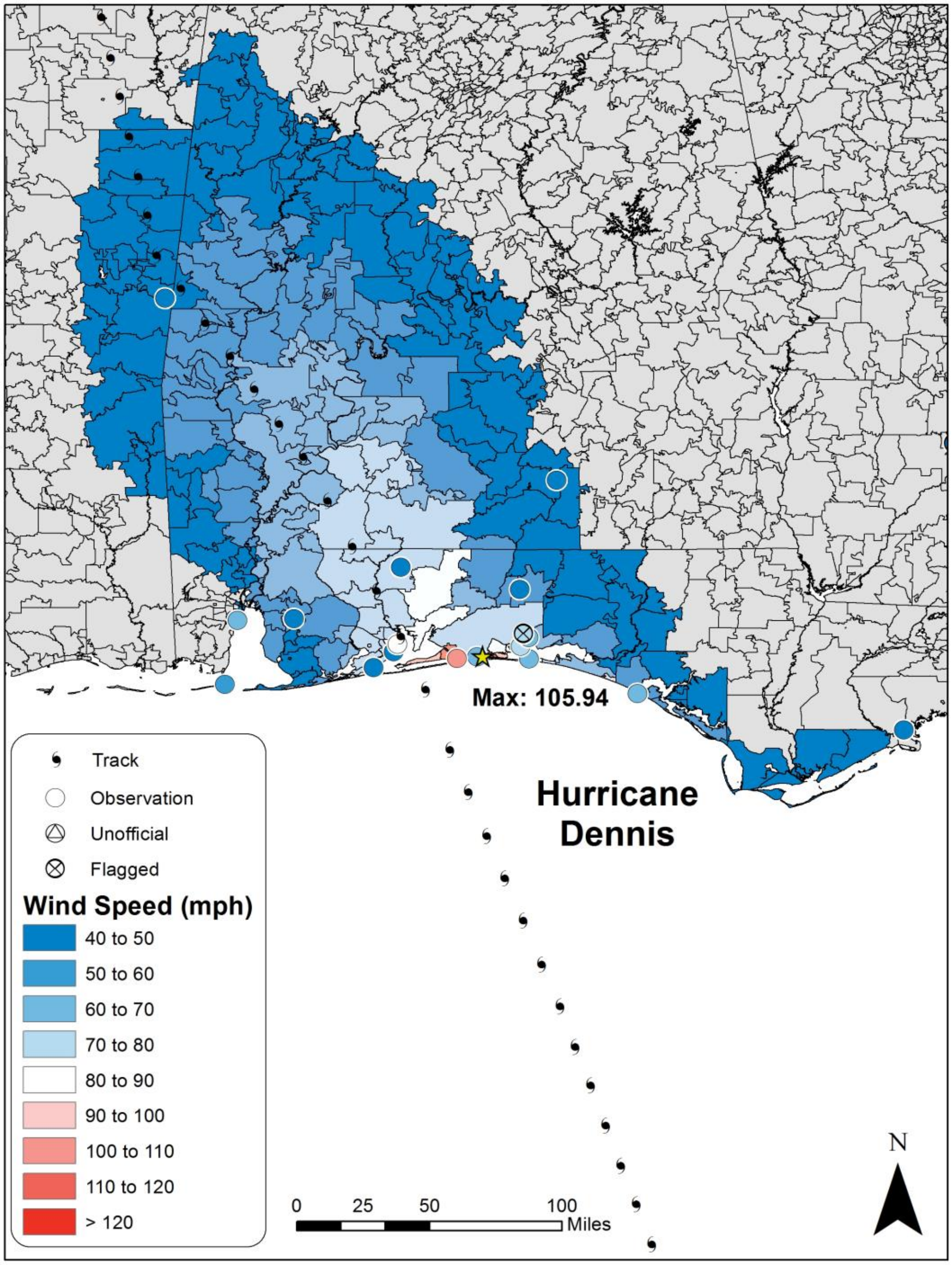


Figure 12. Observed and Modeled Wind Speeds, Hurricane Dennis (2005)

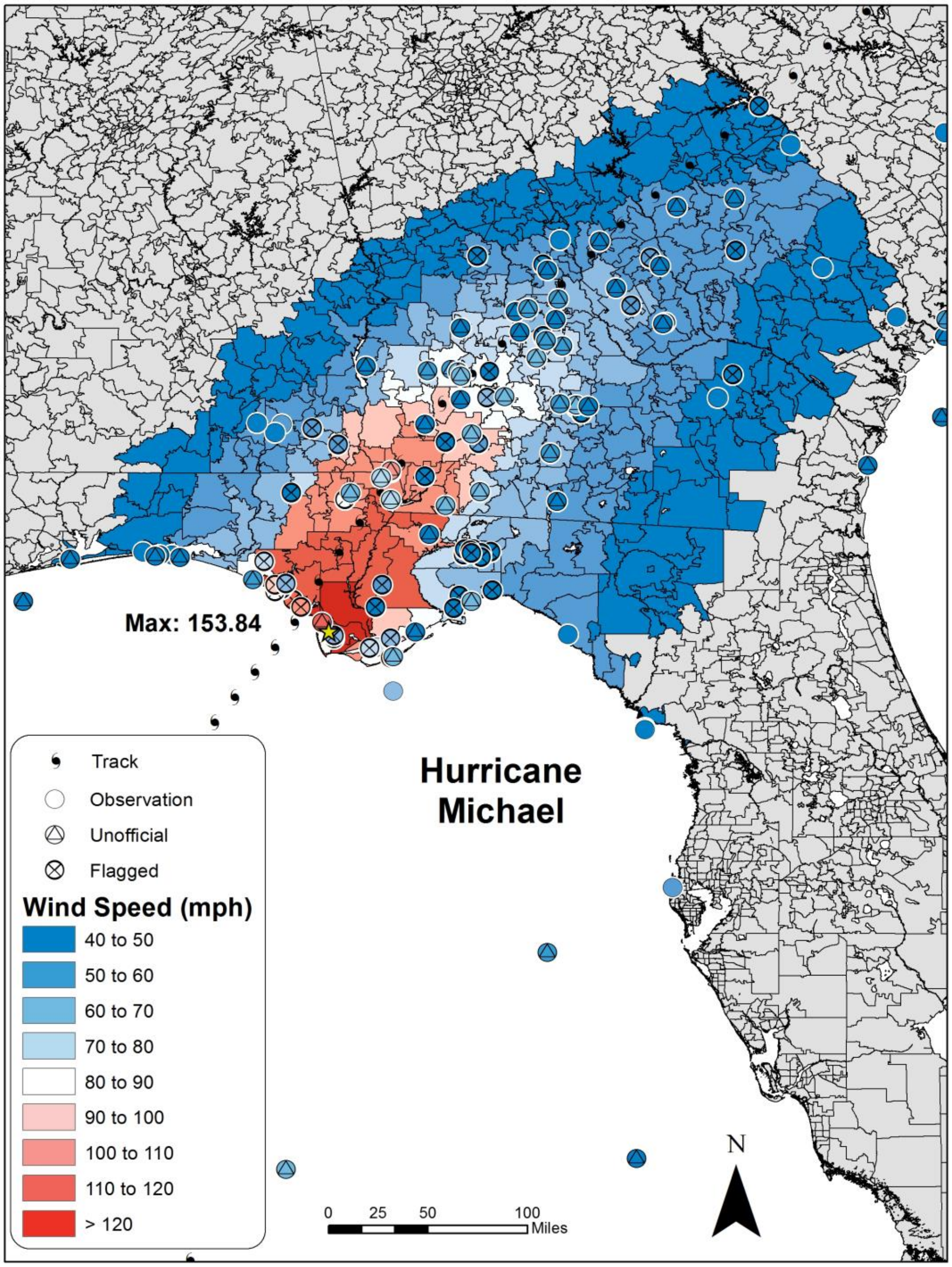


Figure 13. Observed and Modeled Wind Speeds, Hurricane Michael (2018)

8. 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 model these 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.

9. Describe any variations in the treatment of the hurricane model windfield for stochastic versus historical storms and justify this variation.

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

10. Provide a completed Form M-2, Maps of Maximum Winds. Explain the differences between the spatial distributions of maximum winds for open terrain and actual terrain for historical storms. Provide a link to the location of the form.

Link: Form M-2: Maps of Maximum Winds

The use of open versus actual terrain generally results in higher wind speeds in the open terrain cases due to the lower average friction relative to actual terrain.

Standard M-5: Hurricane Landfall and Over-Land Weakening Methodologies

Relevant Form

- *G-2, Meteorological Standards Expert Certification*

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

The model's over-land weakening rates, or filling rates, compare favorably with the historical records for storms of all intensities and are consistent with filling rate methodologies published in peer reviewed journals. The functional form of the inland decay model (shown in Equation 1) is similar to that proposed by Kaplan and DeMaria (1995) which is still commonly used today.

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.

Disclosures

1. Describe and justify the functional form of hurricane decay rates used by the hurricane model.

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 (i.e. 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 than a slow-moving storm with the same initial intensity (pressure deficit).

The functional form of the pressure deficit decay function is:

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

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 to the model's standard filling relationships are allowed 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 work 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° latitude. Within the state of Florida, such perturbations occur only in a very small number of stochastic events.

2. *Provide a graphical representation of the modeled decay rates for Florida hurricanes over time compared to wind observations.*

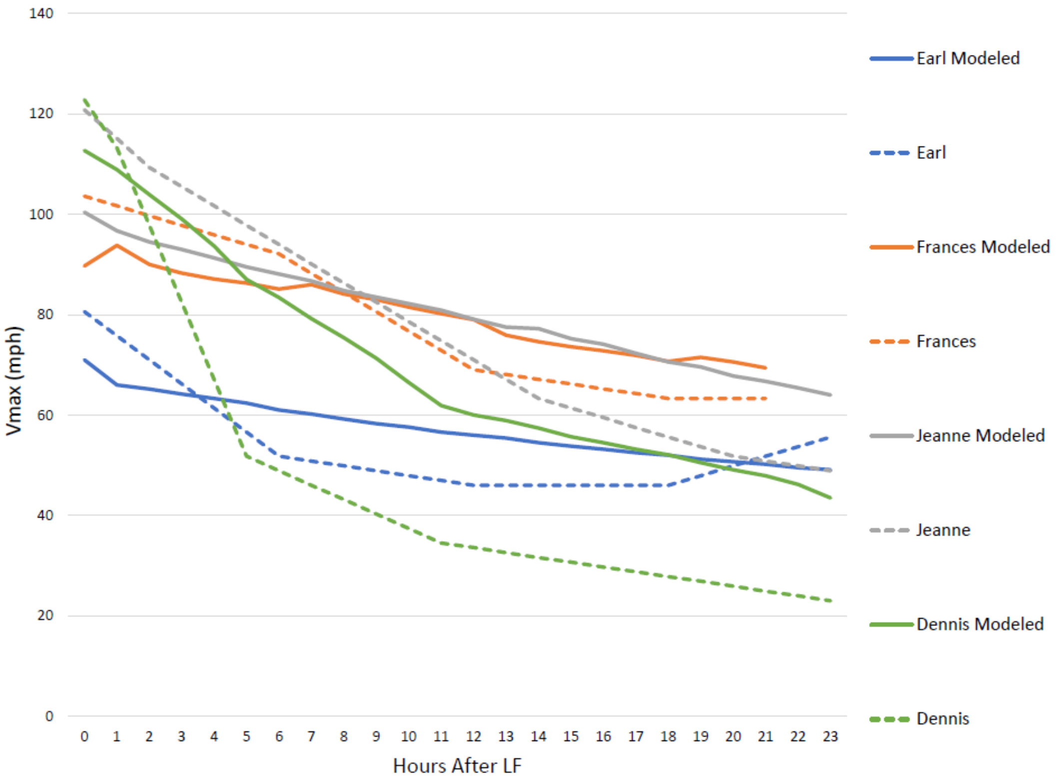


Figure 14. Modeled decay in Vmax as a Function of Hour After Landfall Compared to Historical Florida Hurricanes

Figure 14 shows a comparison of the modeled decay in Vmax over land for 4 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 AIR's modeled representation of storm intensity decay in Vmax. The modeled decay shows a similar behavior to the HURDAT Vmax, decreasing while translating over land.

3. Describe the transition from over-water to over-land boundary layer simulated in the hurricane model.

A hurricane travelling inland encounters different types of terrain, and the associated wind speeds will adjust to the new underlying surface. The distance over which this adjustment takes place is used to define an averaging distance. As the wind encounters the land surface, downwind of any large-scale water body (e.g. ocean, Lake Okeechobee), a new boundary layer develops. The use of the averaging distance allows for a smooth and realistic transition at the boundary between these two surfaces. An adjustment is made to wind speeds modeled near the coast to account for the period before which over-water winds have settled to the underlying land surface. This adjustment is a function of the percentage of water within the directional averaging distance, as well as wind speed and is based on the work of Powell et al., (2003).

In addition, the direction of the wind at a given time is also considered. The wind direction at a given location is computed during each modeled wind computation time step, and the land characteristics upwind of the location are used in making the local wind adjustments.

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 multiple landfalling storms, the radial profile is restored over water and allowed to decay again during subsequent landfalls.

5. Describe the representation in the hurricane model of passage over non-continental 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.

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 Standard M-5, Disclosure 1.

Standard M-6: Logical Relationships of Hurricane Characteristics

Relevant Forms

- *G-2, Meteorological Standards Expert Certification*
- *M-2, Maps of Maximum Winds*
- *M-3, Radius of Maximum Winds and Radii of Standard Wind Thresholds*

See Appendix 2: Meteorological Standards

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 AIR wind model uses, predicts the wind field asymmetry amplitude (magnitude) increases with increased storm translation speed.

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

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 total wind associated with the storm.

2. Discuss the impact of surface roughness on mean windspeeds.

The local surface roughness is characterized by an effective roughness length, which is a weighted average of upwind roughness length values derived from the Land Use-Land Cover database. As air flows toward a location, it is affected by the surface roughness, resulting in a general wind deceleration by the friction force. The magnitude of the wind speed decrease, represented by the Friction Factor, is proportional to the effective roughness length.

3. Provide a completed Form M-3, Radius of Maximum Winds and Radii of Standard Wind Thresholds. Provide a link to the location of the form.

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

4. Discuss the radii values for each wind threshold in Form M-3, Radius of Maximum Winds and Radii of Standard Wind Thresholds, with reference to available hurricane observations such as those in HURDAT2. 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	28.77	690.47	112.20
980	11.51	345.23	24.69	31.65	621.42	133.78
970	11.51	247.42	31.65	43.15	555.25	149.60
960	14.38	247.42	43.15	46.03	724.99	163.99
950	17.26	189.88	48.91	69.05	598.41	159.67
940	21.58	145.77	46.03	80.55	477.57	149.60
930	23.02	94.94	51.79	83.43	241.66	166.86
920	27.33	86.31	51.79	112.20	187.00	149.60
910	46.03	94.94	60.42	129.46	210.02	161.11
900	57.54	92.06	60.42	161.11	197.07	175.49

The wind radii values in Form M-3 have been compared to data from the HURDAT2 dataset (see Table 3 above) for the 40 and 73 mph wind radii. 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.

Forms included in Appendix 2: Meteorological Standards

Statistical Standards

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

Relevant Forms

- G-3, Statistical Standards Expert Certification
- M-1, Annual Occurrence Rates
- S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year
- S-2, Examples of Hurricane Loss Exceedance Estimates
- S-3, Distributions of Stochastic Hurricane Parameters
- S-4, Validation Comparisons
- S-5, Average Annual Zero Deductible Statewide Hurricane Loss Costs – Historical versus Modeled
- A-8, Hurricane Probable Maximum Loss for Florida

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

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

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

1. Provide a completed Form S-3, Distributions of Stochastic Hurricane Parameters. 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.

Link: 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. since 1900. 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 (2.05, with 3 degrees of freedom) is small and its associated p-value (0.56) indicates no lack of fit.

Landfall Location

The probability distribution for landfall location is based on the number of historical hurricane landfalls per approximately 50 nautical mile segment along the coast. Due to the relative scarcity of historical data at this spatial resolution the estimation involves smoothing of the historical frequencies as well as meteorological adjustments to arrive at credible landfall probabilities. The checks performed on the final landfall distribution include graphical and numerical comparisons of historical and simulated landfall frequencies as well as the Kolmogorov-Smirnov goodness-of-fit tests for annual frequency for landfall locations. The resulting p-value is 0.88, indicating no lack-of-fit.

Central Pressure

The probability distribution for central pressure is a Weibull distribution with the shape and scale parameters estimated for each 100-mile coastline segment. The distributions of the historical data on central pressure are typically skewed since very intense hurricanes are less frequent than weak hurricanes. The two-parameter Weibull distribution has a very flexible shape and is able to capture the skewness present in the historical data on central pressure.

The maximum likelihood method is used for the parameter estimation. A second calculation combines the data for six larger regions and computes Weibull parameter estimates for each of these regions. The final probability distribution used for each segment is a mixture of the segment and regional Weibull distributions.

The adequacy of the segment and regional Weibull distributions is tested using the Kolmogorov-Smirnov goodness-of-fit test. The empirical and fitted probability distributions are also compared using Q-Q plots and other graphical methods. In addition, the historical and simulated central pressure distributions are compared graphically for each 100-mile coastal segment. The various checks performed, along with associated p-values, confirm that the fitted distributions provide a reasonable approximation for central pressure. An example of examination for goodness-of-fit about the probability distribution for central pressure can be seen in Figure 20, indicating no lack-of-fit. 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 AIR model is 0.78, 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 simulated values is demonstrated using scatter diagrams, as well as segment-by-segment comparisons of observed and simulated values. For Florida and adjacent states, the p-value from the Kolmogorov-Smirnov goodness-of-fit test for the historical and simulated radius of maximum winds distributions is 0.27, indicating consistency between the historical and model distributions.

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 Anderson-Darling goodness-of-fit test for the historical distribution against the log-normal distribution is 0.72. Further, the results of the two-sample Kolmogorov-Smirnov test for the historical distribution versus the simulated distribution again confirm the consistency between the two.

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 0.60, 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.

Storm Tracks

AIR'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 AIR 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, AIR 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.

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

Extensive comparisons were performed between model generated wind speeds and observations to check for spatial extent of the winds and their magnitude. Observational data have been gathered from NHC's Tropical Cyclone Reports as well as other data sources, like HURDAT2, dropsonde data, Texas Tech high-resolution data, and various published reports for 36 historical storms (11 Florida storms). Comparisons performed include scatter plots of model winds versus observed winds, wind distribution against distance from the eye and storm model footprint (hourly or over storm lifetime) versus point wind observations, h*Wind data (Landsea et al., 2004; Powell et al., 1998) or Extended Best Track significant wind radii (Demuth et al., 2006). Mean statistics were computed for wind differences over all amplitudes or at different wind bands. Table 4 and Figure 15 through Figure 17 present a set of validation tests performed for Hurricane Andrew (1992).

Table 4. Validation Tests Performed for Hurricane Andrew (1992)

Storm	Sample Size	ExplVar (%)	Correlation	MBE (mph)
Andrew	31	82.81	0.91	5.40

where MBE = Mean Bias Error = Mean(ModelWind) - Mean(ObsWind)

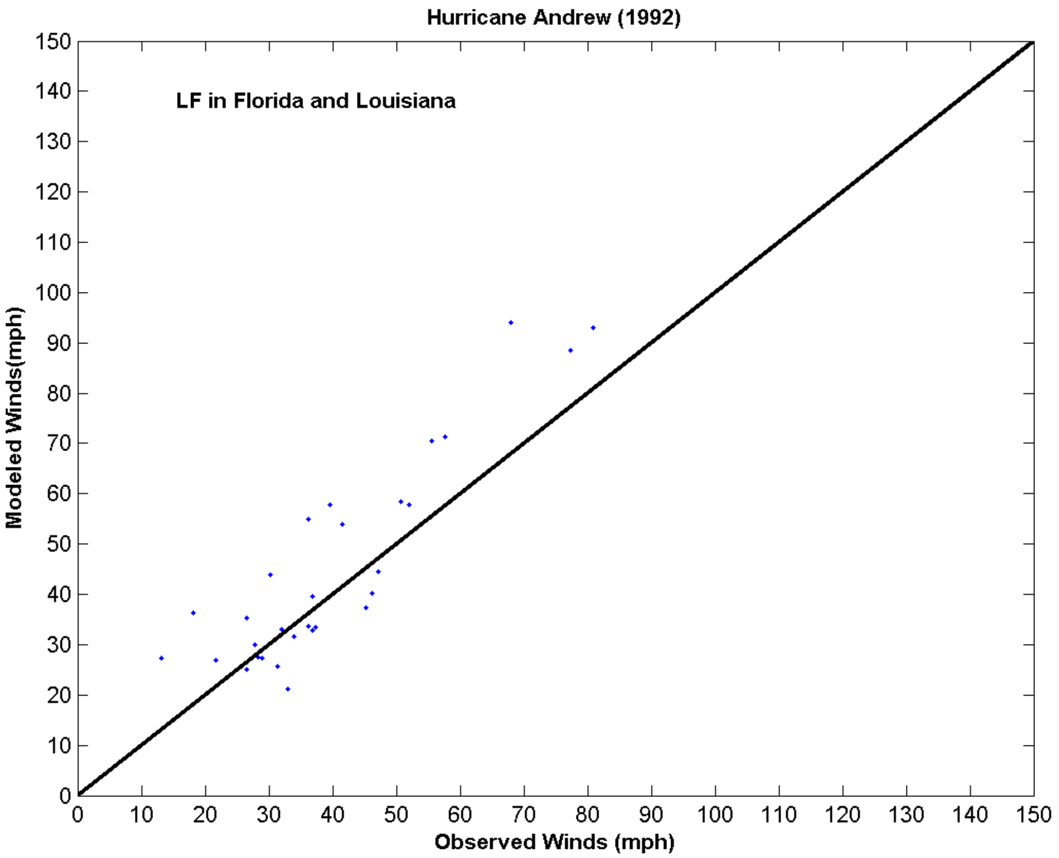


Figure 15. Modeled Versus Observed Surface Winds for Hurricane Andrew (1992)

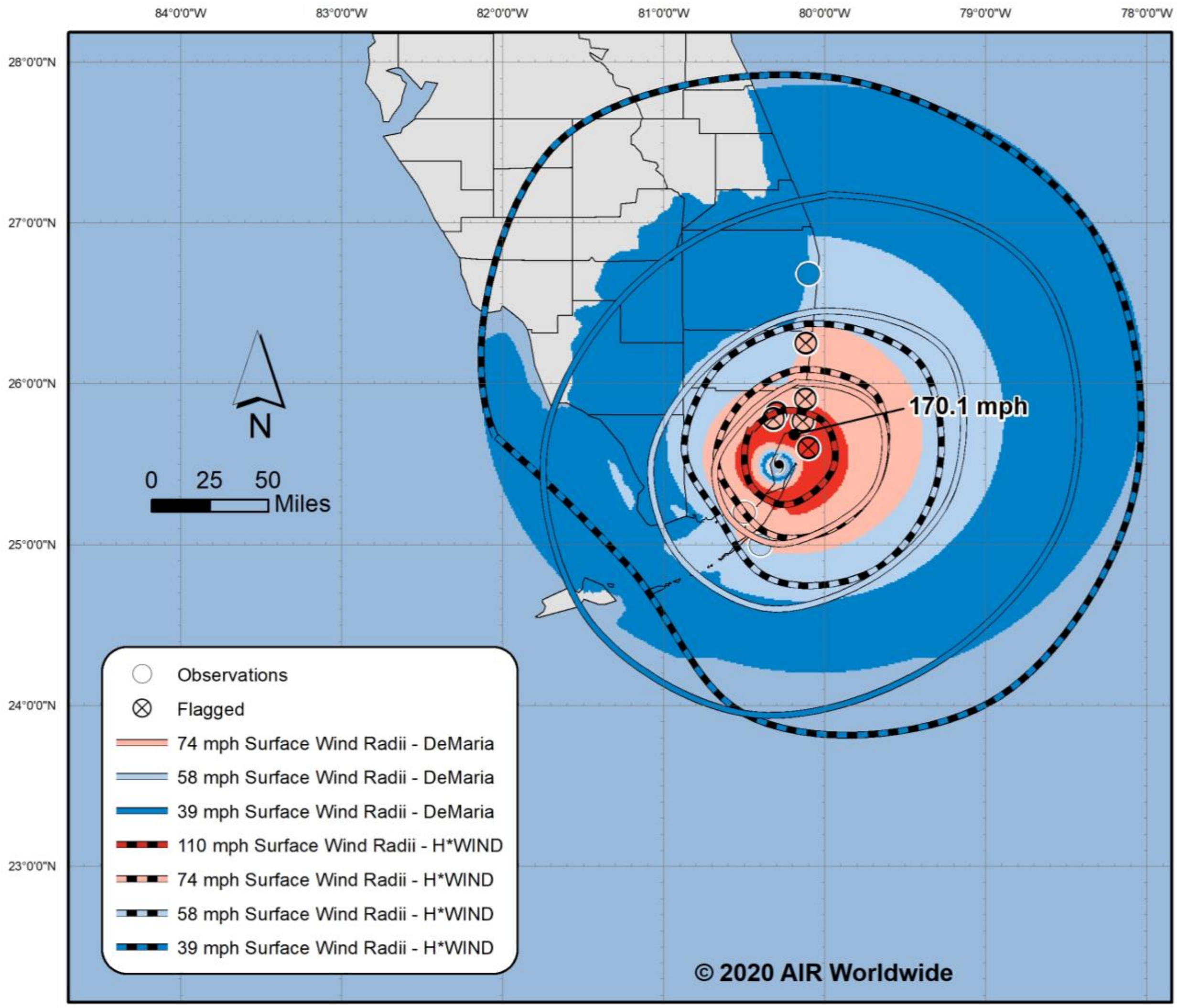


Figure 16. Snapshot of Hurricane Andrew's Footprint at Landfall (Colors). Overlaid Are Observed Wind Radii (Contours) Derived from DeMaria and H*wind, along with Station Wind Observations (Colored Circles)

The minimum wind speed was not included in Figure 16 and Figure 17. The wind footprints shown on the maps have a minimum wind speed of 39 mph.

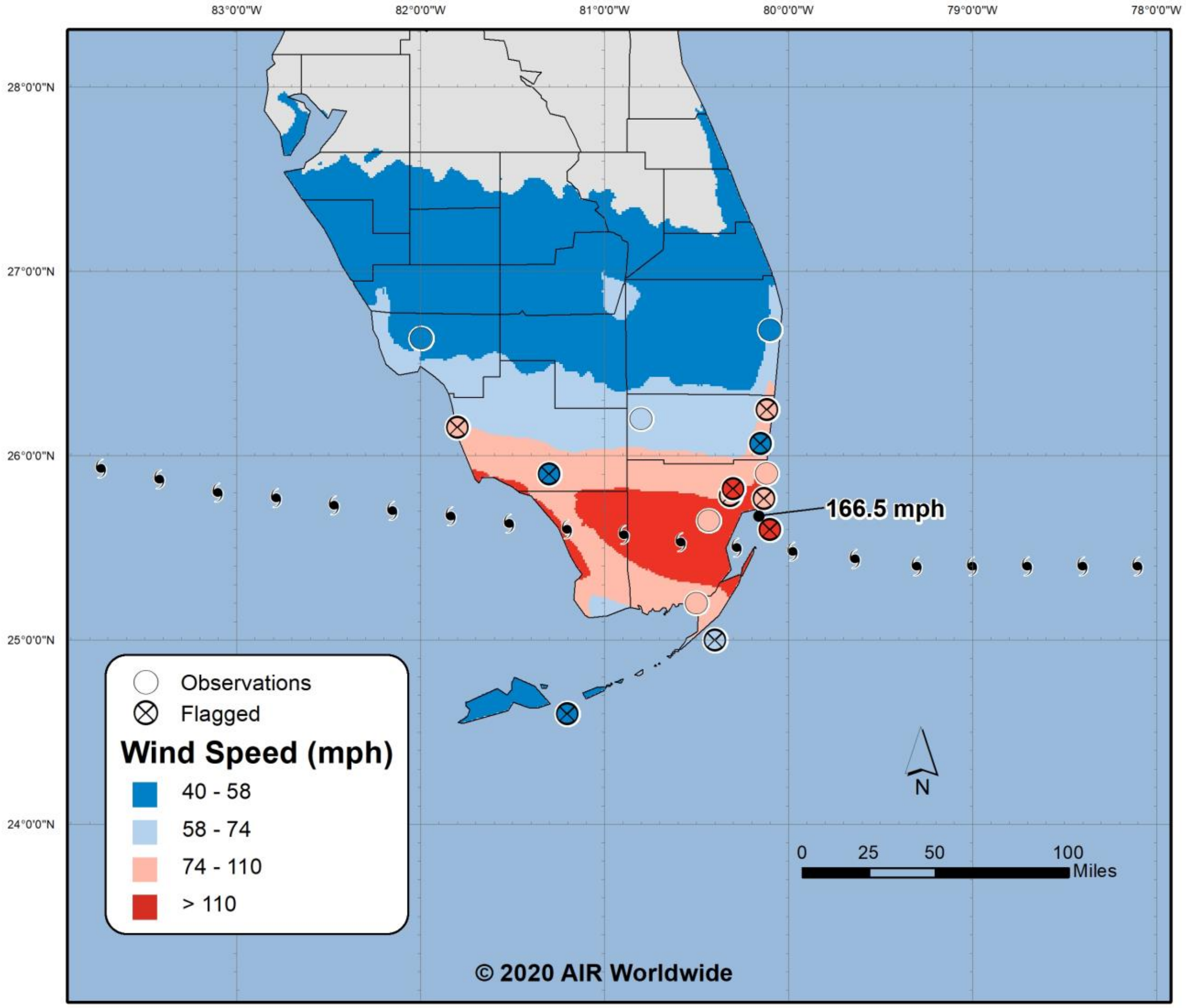


Figure 17. Hurricane Andrew's Maximum Wind Footprint (Colors) Overlaid With Station Wind

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

AIR 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).

4. *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 AIR 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 2010 submission. 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.

5. *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 119 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.

6. *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 18 shows the historical distribution of annual U.S. landfalls alongside the modeled distribution in the AIR 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 1.82, (p-value = 0.87 on 5 degrees of freedom), confirming consistency between the modeled and historical hurricane frequencies. The goodness-of-fit test result reported in Disclosure 1 also substantiates the choice of a negative binomial model for this variable.

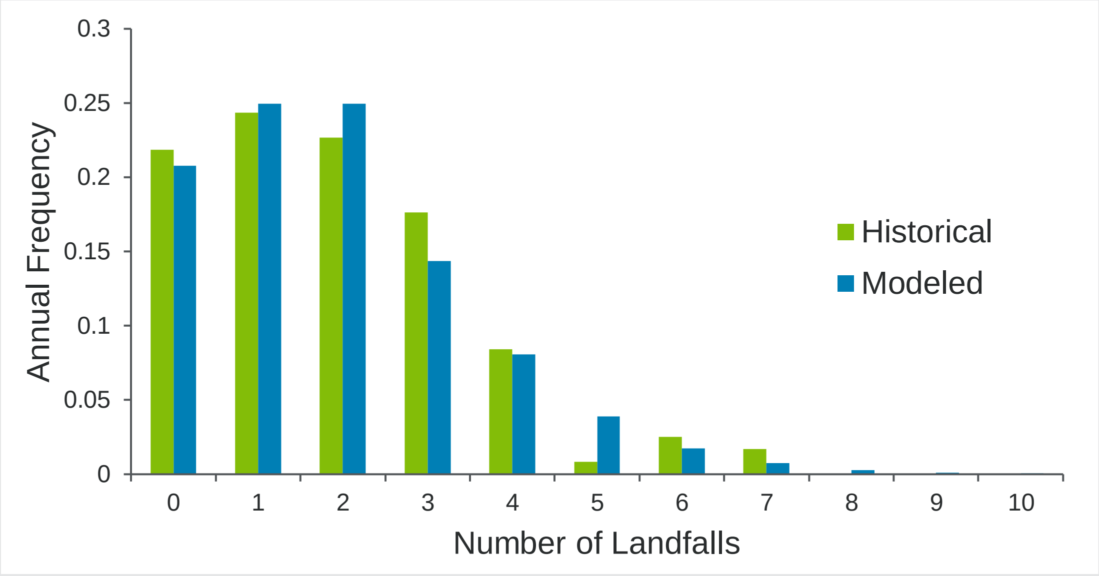


Figure 18. Historical and Modeled U.S. Annual Landfall Frequency Distributions

Hurricane Tracks

The maps in Figure 19 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.

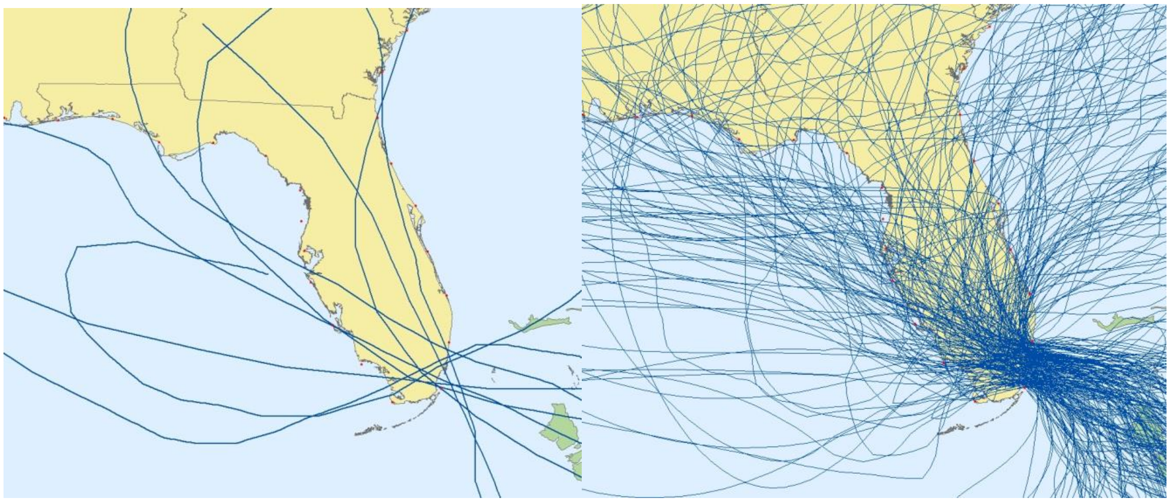
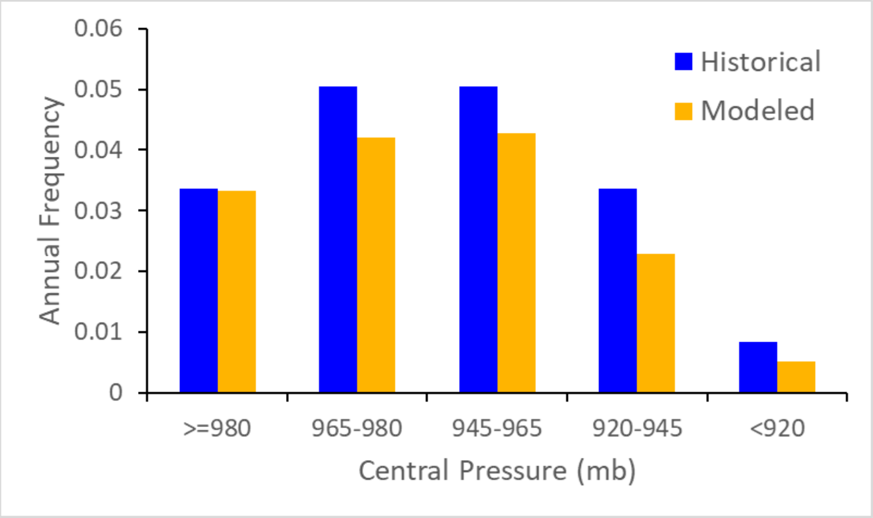
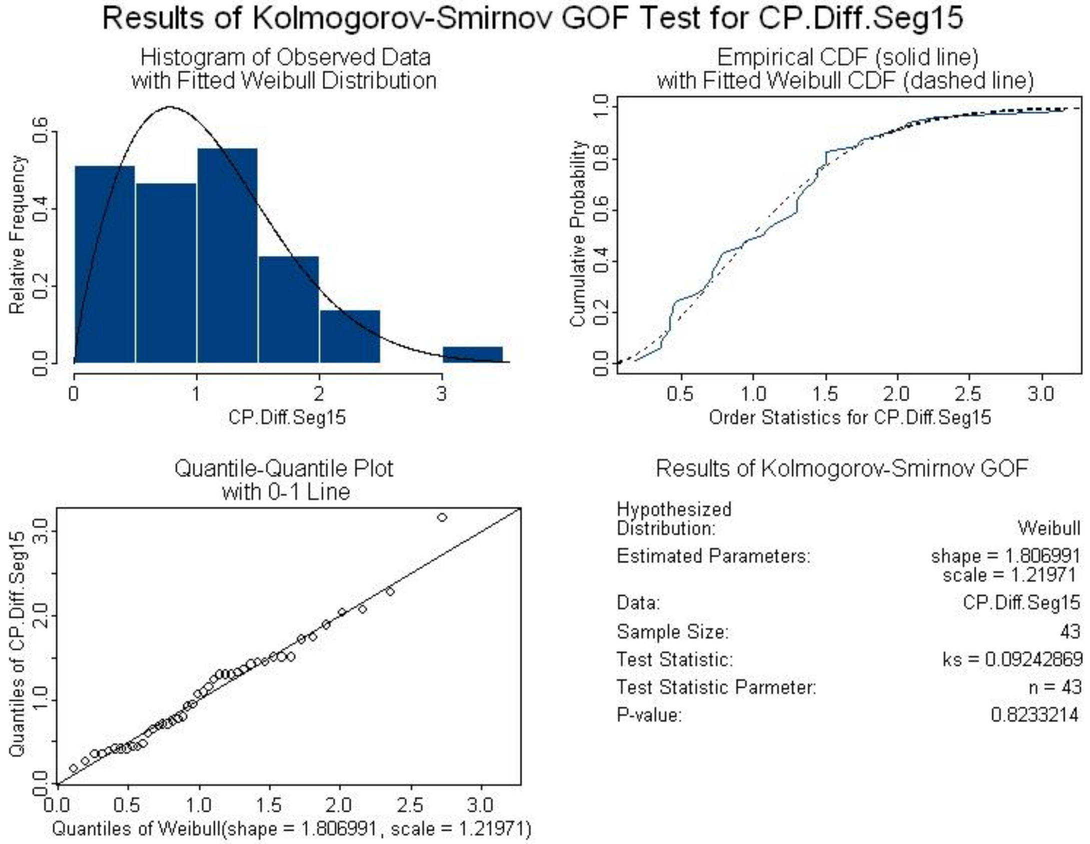


Figure 19. Historical (left) and Simulated (Right) Hurricanes Landfalling in SE Florida

Intensities

Figure 20 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.




Results of Kolmogorov-Smirnov GOF Test for CP.Diff.Seg15

Results of Kolmogorov-Smirnov GOF

Hypothesized Distribution:	Weibull
Estimated Parameters:	shape = 1.806991 scale = 1.21971
Data:	CP.Diff.Seg15
Sample Size:	43
Test Statistic:	ks = 0.09242869
Test Statistic Parmeter:	n = 43
P-value:	0.8233214

Figure 20. Goodness-of-Fit Comparisons for a 100-Mile Florida Segment

Physical Damage

Figure 21 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 0.32.

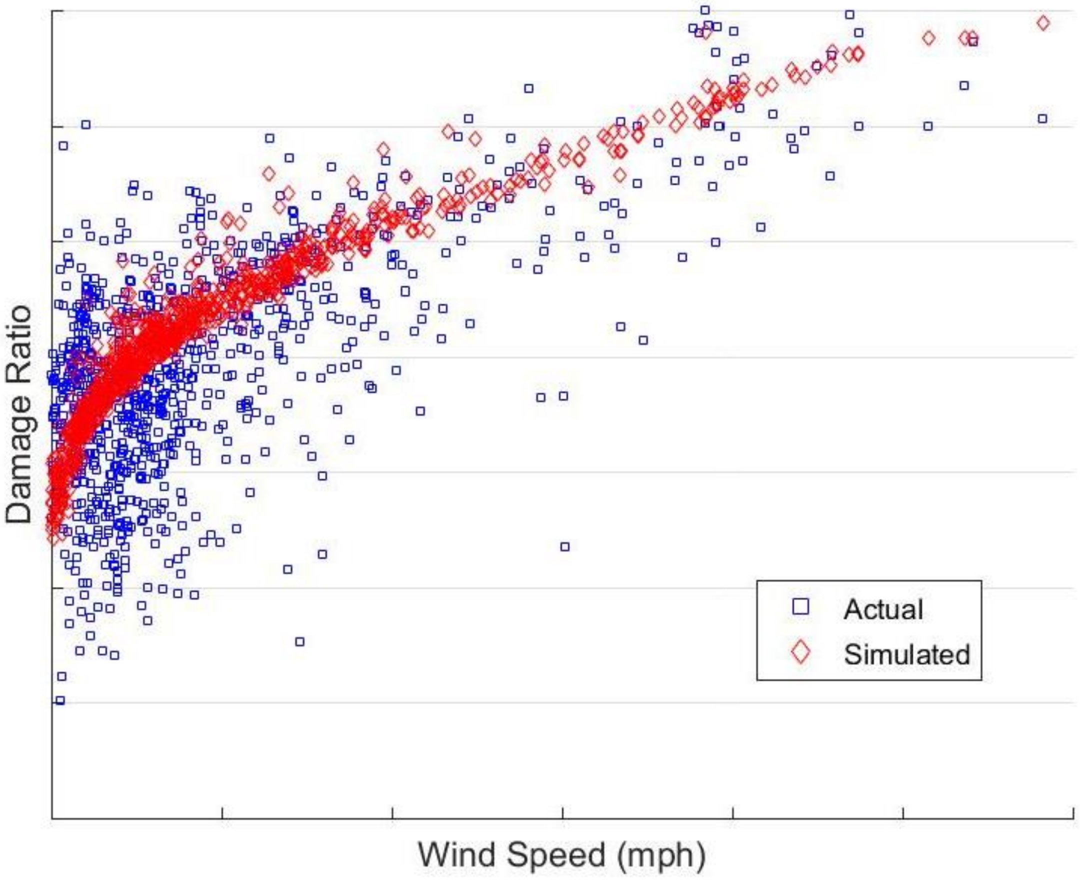


Figure 21. Sample Damage Ratio Comparison

7. Provide a completed Form S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year. Provide a link to the location of the form.

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

8. Provide a completed Form S-2, Examples of Hurricane Loss Exceedance Estimates. Provide a link to the location of the form.

Link: Form S-2: Examples of Hurricane Loss Exceedance Estimates

Standard S-2: Sensitivity Analysis for Hurricane Model Output

Relevant Forms

- *G-3, Statistical Standards Expert Certification*
- *S-6, Hypothetical Events for Sensitivity and Uncertainty Analysis*

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

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 AIR, as well as the Form S-6 analysis performed as part of our submission under the 2009 Standards.

The Form S-6 analysis 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 22, Figure 23, and Figure 24 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.

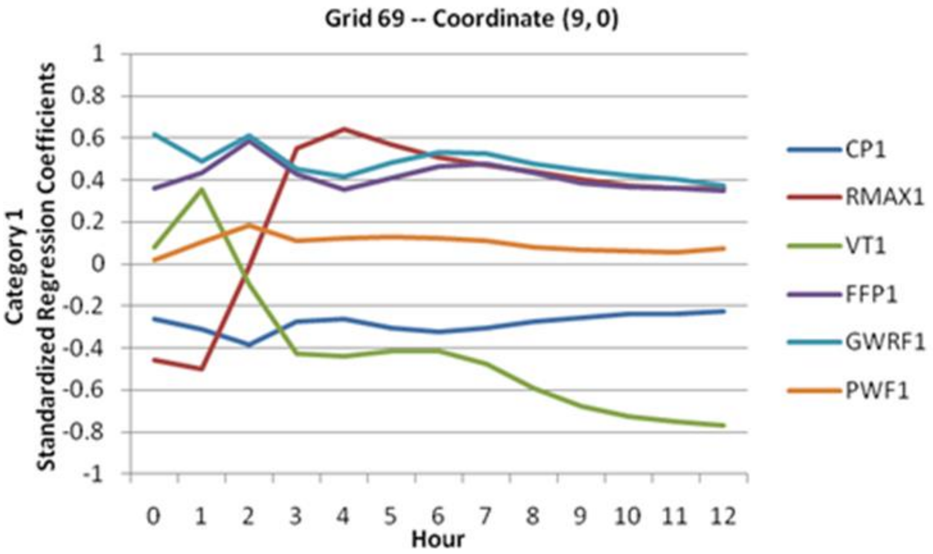


Figure 22. Standardized Regression Coefficients vs. Time at Grid Coordinates (9,0) for Category 1

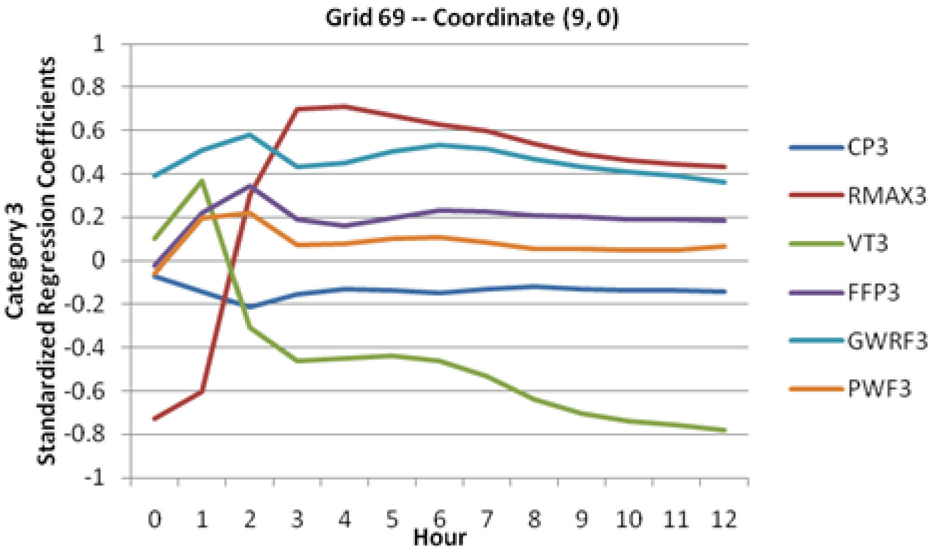


Figure 23. Standardized Regression Coefficients vs. Time at Grid Coordinates (9,0) for Category 3

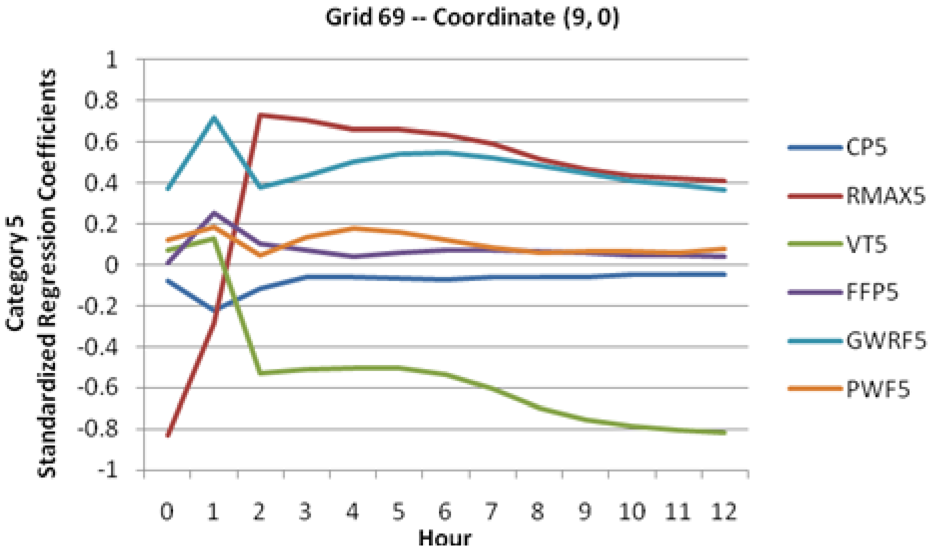


Figure 24. Standardized Regression Coefficients vs. Time at Grid Coordinates (9,0) for Category 5

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.*

AIR has identified, discussed, and disclosed all input variables that impact the output values in Disclosure 1. Therefore, no further information can be disclosed here.

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 AIR 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.

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.

5. ***Provide a completed Form S-6, Hypothetical Events for Sensitivity and Uncertainty Analysis. (Requirement for hurricane models submitted by modeling organizations which have not previously provided the Commission with this analysis. For hurricane models previously found acceptable, the Commission will determine, at the meeting to review modeling organization submissions, if an existing modeling organization will be required to provide Form S-6, Hypothetical Events for Sensitivity and Uncertainty Analysis, prior to the Professional Team on-site review). If applicable, provide a link to the location of the form.***

Form S-6 was submitted and accepted as a requirement under the 2009 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 Statistical Standards S-2 and S-3.

Standard S-3: Uncertainty Analysis for Hurricane Model Output

Relevant Forms

- *G-3, Statistical Standards Expert Certification*
- *S-6, Hypothetical Events for Sensitivity and Uncertainty Analysis*

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.

AIR 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

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 AIR, 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 25 to Figure 27, 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.

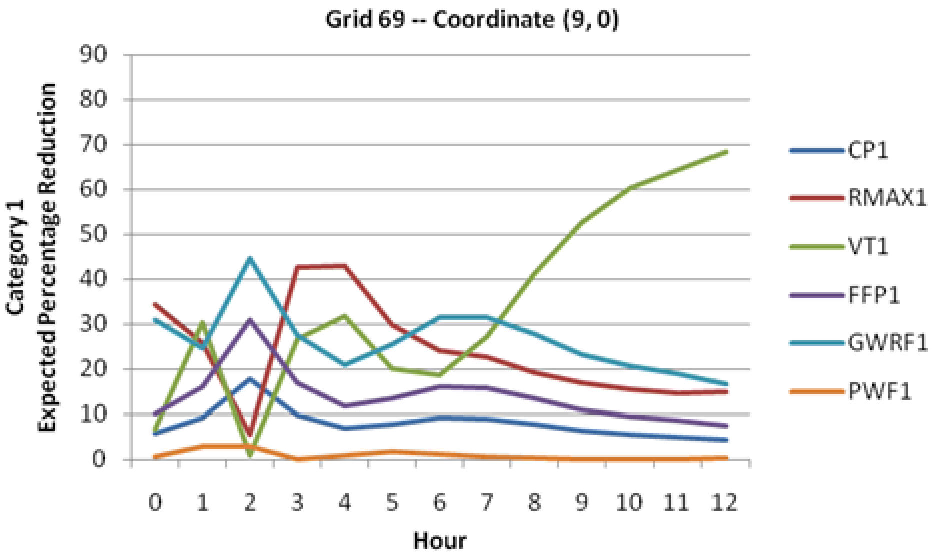


Figure 25. Expected Percentage Reduction vs. Time at Grid Coordinates (9,0) for Category 1

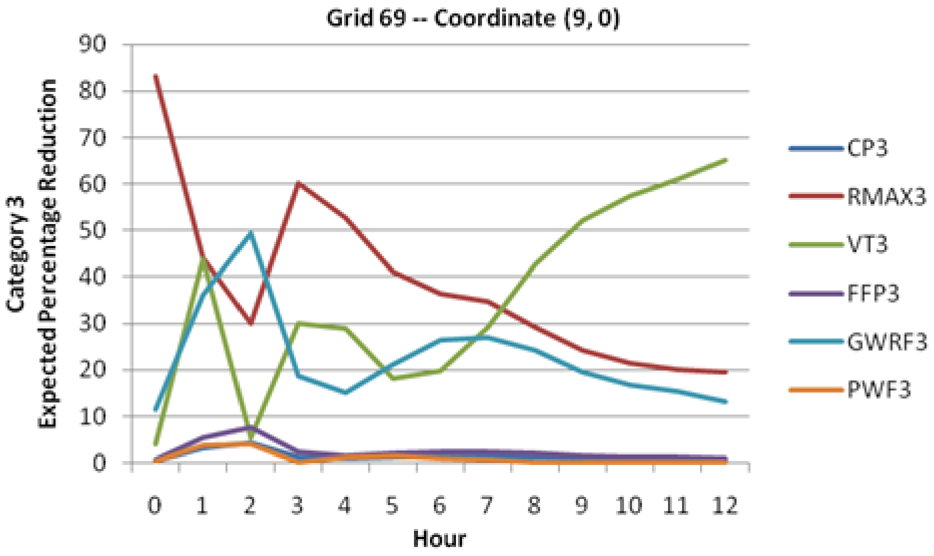


Figure 26. Expected Percentage Reduction vs. Time at Grid Coordinates (9,0) for Category 3

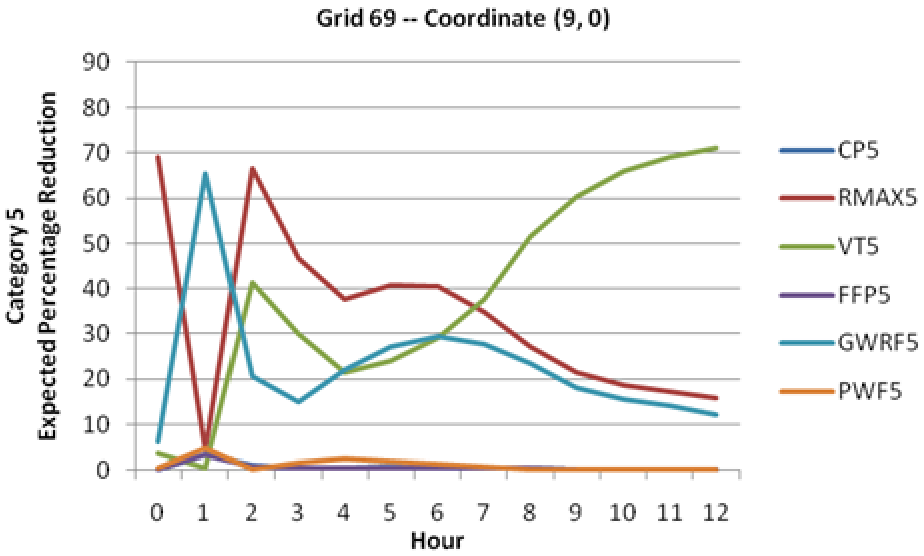


Figure 27. Expected Percentage Reduction vs. Time at Grid Coordinates (9,0) for Category 5

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.

Our work 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.

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

Past studies performed by AIR 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.

4. Form S-6, Hypothetical Events for Sensitivity and Uncertainty Analysis, if disclosed under Standard S-2, Sensitivity Analysis for Hurricane Model Output, will be used in the verification of Standard S-3, Uncertainty Analysis for Hurricane Model Output.

Form S-6 was submitted and accepted as a requirement under the 2009 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 Statistical Standards S-2 and S-3.

Standard S-4: County Level Aggregation

Relevant Form

- *G-3, Statistical Standards Expert Certification*

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

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.***

AIR uses constrained Monte Carlo simulation to obtain the average annual loss 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

Relevant Forms

- *G-3, Statistical Standards Expert Certification*
- *S-4, Validation Comparisons*

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

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

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 2004 and 2005 hurricane seasons.

Table 5 through Table 10 show how AIR's modeled losses compare, in total and by coverage and construction, to the actual losses of specific client companies for key storms including 2004 and 2005 storms: 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.

Table 5. Actual vs. Modeled Losses for Eight Storms and Eight Companies (Personal Residential)

Event	Company	Actual Loss ($)	Modeled Loss ($)
Andrew	A	699,699,029	595,928,037
Andrew	C	30,876,447	57,406,890
Andrew Total		**730,575,476**	**653,334,927**
Charley	G	14,393,377	12,225,034
Charley	I	12,923,883	18,973,778
Charley	J	67,874,885	56,231,855
Charley Total		**95,192,145**	**87,430,667**
Erin	B	2,752,119	4,727,107
Erin	C	11,533,903	18,640,760
Erin Total		**14,286,022**	**23,367,867**
Frances	G	10,767,210	7,500,672
Frances	I	10,766,571	14,441,517
Frances	J	10,712,272	26,125,952
Frances Total		**32,246,053**	**48,068,141**
Ivan	G	3,912,200	3,048,616
Ivan	I	5,943,129	43,784,605
Ivan	J	1,631,417	1,350,067
Ivan Total		**11,486,746**	**48,183,288**
Jeanne	G	2,721,086	5,673,251
Jeanne	I	9,551,018	11,542,923
Jeanne	J	17,743,163	22,078,184
Jeanne Total		**30,015,267**	**39,294,358**
Wilma	M	14,345,569	15,042,649
Wilma	N	152,698,832	167,597,568
Wilma Total		**167,044,401**	**182,640,217**
Katrina	N	22,480,522	37,487,302
Katrina Total		**22,480,522**	**37,487,302**

Table 6. Actual vs. Modeled Losses for Six Storms and Two Companies (Commercial Residential)

Event	Company	Actual Loss ($)	Modeled Loss ($)
Charley	N	65,465,443	104,763,971
Charley Total		**65,465,443**	**104,763,971**
Frances	N	60,324,157	33,332,578
Frances Total		**60,324,157**	**33,332,578**
Ivan	N	22,407,198	23,429,217
Ivan Total		**22,407,198**	**23,429,217**
Jeanne	N	11,708,119	24,733,277
Jeanne Total		**11,708,119**	**24,733,277**
Wilma	M	14,953,340	37,493,925
Wilma	N	125,190,942	99,627,320
Wilma Total		**140,144,282**	**137,121,245**
Katrina	N	7,139,327	12,402,655
Katrina Total		**7,139,327**	**12,402,655**

Table 7. 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	460,970,299
A	Andrew	C	22,888,773	41,025,592
A	Erin	C	10,474,623	16,130,589
A	Charley	G	12,330,422	10,306,776
A	Frances	G	9,755,813	6,645,652
A	Ivan	I	5,089,896	37,912,173
A	Jeanne	I	8,517,935	10,039,678
A	Charley	J	62,338,151	49,964,715
A	Frances	J	10,271,271	24,045,849
A	Wilma	M	14,021,469	13,602,701
A	Wilma	N	51,124,993	41,843,070
A	Katrina	N	6,527,939	4,930,837
Total			**692,394,305**	**717,417,931**
C	Andrew	A	176,041,470	83,707,283
C	Andrew	C	6,160,344	12,264,078
C	Erin	C	815,171	2,216,438

Coverage	Event	Company	Actual Loss ($)	Modeled Loss ($)
C	Charley	G	1,576,019	1,534,499
C	Frances	G	772,325	718,100
C	Ivan	I	697,428	5,148,421
C	Jeanne	I	791,274	1,322,490
C	Charley	J	4,087,662	4,582,308
C	Frances	J	315,552	1,738,405
C	Wilma	M	270,656	1,075,027
C	Wilma	N	1,813,070	3,261,772
C	Katrina	N	233,899	257,680
Total			**193,574,870**	**117,826,501**
D	Andrew	A	44,604,539	51,250,456
D	Andrew	C	1,827,330	4,117,220
D	Erin	C	244,109	293,732
D	Charley	G	486,936	383,760
D	Frances	G	239,072	136,920
D	Ivan	I	155,805	724,011
D	Jeanne	I	241,809	180,755
D	Charley	J	1,449,072	1,684,832
D	Frances	J	125,449	341,697
D	Wilma	M	53,444	364,921
D	Wilma	N	369,507	203,009
D	Katrina	N	48,011	7,917
Total			**49,845,083**	**59,689,230**

Table 8. 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	19,740,375
Frame	Andrew	C	8,987,526	15,563,109
Frame	Erin	C	6,881,690	10,377,772
Frame	Erin	B	2,646,930	1,694,323
Frame	Charley	G	2,435,653	2,173,121
Frame	Frances	G	4,553,820	2,168,084
Frame	Ivan	I	2,325,399	17,600,396

Construction	Event	Company	Actual Loss ($)	Modeled Loss ($)
Frame	Jeanne	I	2,939,507	3,297,537
Frame	Charley	J	8,453,254	11,677,877
Frame	Frances	J	2,851,694	4,485,737
Frame	Wilma	M	1,078,031	898,642
Frame	Wilma	N	15,303,256	22,457,814
Frame	Katrina	N	1,380,416	2,239,289
Total			**109,302,920**	**114,374,076**
Masonry	Andrew	A	650,233,285	576,187,663
Masonry	Andrew	C	19,929,848	35,451,963
Masonry	Erin	C	2,987,052	4,482,609
Masonry	Charley	G	11,908,319	9,972,521
Masonry	Frances	G	6,135,762	5,243,734
Masonry	Ivan	I	1,029,801	3,637,574
Masonry	Jeanne	I	6,082,968	7,472,081
Masonry	Charley	J	59,301,884	44,373,846
Masonry	Frances	J	7,830,728	21,527,282
Masonry	Wilma	M	12,859,659	13,274,562
Masonry	Wilma	N	115,532,204	107,503,414
Masonry	Katrina	N	11,937,900	17,993,886
Total			**905,769,410**	**848,597,681**
Manufactured Home	Andrew	C	485,193	2,675,983
Manufactured Home	Erin	C	663,292	3,242,002
Manufactured Home	Erin	B	105,189	729,114
Manufactured Home	Wilma	N	15,874,921	17,134,764
Manufactured Home	Katrina	N	1,466,506	985,886
Total			**18,595,101**	**24,767,749**

Table 9. 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	1,333,435
Concrete	Frances	N	18,957,693	5,818,701
Concrete	Ivan	N	2,819,463	4,912,617
Concrete	Jeanne	N	1,170,862	4,210,263

Construction	Event	Company	Actual Loss ($)	Modeled Loss ($)
Concrete	Wilma	M	2,221,720	2,302,909
Concrete	Wilma	N	60,983,157	36,680,859
Concrete	Katrina	N	2,810,102	3,528,794
Total			**90,989,711**	**58,787,578**
Masonry	Charley	N	14,725,592	19,723,684
Masonry	Frances	N	31,950,677	15,438,342
Masonry	Ivan	N	9,921,781	2,369,939
Masonry	Jeanne	N	5,139,136	11,300,289
Masonry	Wilma	M	11,356,070	31,361,232
Masonry	Wilma	N	57,537,128	50,969,433
Masonry	Katrina	N	4,252,495	7,772,859
Total			**134,882,879**	**138,935,778**

Table 10. Actual vs. Modeled Losses by County for One Company—Hurricane Frances

County	Actual Loss ($)	Modeled Loss ($)
Indian River	129,401	190,373
Martin	162,294	177,023
Okeechobee	107,558	81,063
Palm Beach	1,641,708	2,563,143
St. Lucie	149,397	148,754
Total	**2,190,358**	**3,160,356**

2. *Provide a completed Form S-4, Validation Comparisons. Provide a link to the location of the form.*

Link: Form S-4: Validation Comparisons

Standard S-6: Comparison of Projected Hurricane Loss Costs

Relevant Forms:

- *G-3, Statistical Standards Expert Certification*
- *S-5, Average Annual Zero Deductible Statewide Hurricane Loss Costs – Historical versus Modeled*

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 1900–2018, is $3.198 billion. The average annual statewide personal and commercial residential loss costs, produced by the model using a 50,000-year simulation, is $3.936 billion. The difference between these two sets of numbers is statistically reasonable.

Disclosures

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 AIR Hurricane Model for the U.S. 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 information from data contributing insurers have also been used to validate the simulated loss costs as shown in Standard S-5 above.

As described elsewhere in this document, AIR 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.

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.

3. *Provide a completed Form S-5, Average Annual Zero Deductible Statewide Hurricane Loss Costs – Historical versus Modeled. Provide a link to the location of the form.*

Link: Form S-5: Average Annual Zero Deductible Statewide Hurricane Loss Costs – Historical Versus Modeled

Vulnerability Standards

Standard V-1: Derivation of Building Hurricane Vulnerability Functions

Relevant Forms

- *G-4, Vulnerability Standards Expert Certification*
- *V-1, One Hypothetical Event*
- *A-1, Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code*
- *A-6, Logical Relationship to Hurricane Risk (Trade Secret Item)*

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

The original AIR Hurricane Model for the U.S. 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 loss data from clients.

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

The AIR 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 loss data and findings from damage surveys.

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 AIR Hurricane Model for the U.S. are representative of the building stock in Florida.

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

The AIR Hurricane Model for the U.S. uses vulnerability functions for approximately 32 different residential construction types enumerated in Disclosure V.1.7. 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 AIR's Individual Risk Model (Appendix 9) 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 Disclosure V.1.7.

The AIR 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 is the latest version governing 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 AIR 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 (2015-2020) are considered new from an aging perspective. Between 1995 and 2015, 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 9) 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 more recently FBC 2010). While six unique building categories (described in Appendix 9) 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 9) 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 and 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 AIR 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 AIR model uses the following year built categories: pre-1976, 1976-1993, 1994-1998, 1999-2007 and post 2007.

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

In the AIR Hurricane Model for the U.S., 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 AIR, manufactured homes are defined as a separate construction class along with several others including wood frame, unreinforced and reinforced masonry, reinforced concrete, 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 AIR Hurricane Model for the U.S., separate vulnerability functions are derived by coverage. Disclosure V-1.7 provides more details regarding the same.

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.

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, or and wave action).

The wind vulnerability functions in the AIR Hurricane Model for the U.S. do not include any explicit damage from flood, storm surge, or wave actions. Wind vulnerability functions in the AIR Hurricane Model for the U.S. 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

1. Describe any modifications to the building vulnerability component in the hurricane model since the previously-accepted hurricane model.

The building vulnerability component of the AIR Hurricane Model for the U.S. has been updated since the release of the previously accepted model. The changes since the previously 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 2020. 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 2020.
- 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 2020.
- The logic of roof age assignment has been updated to assign buildings built within the last 10–20 years to have an “average” roof year built when the roof year built is unknown.

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

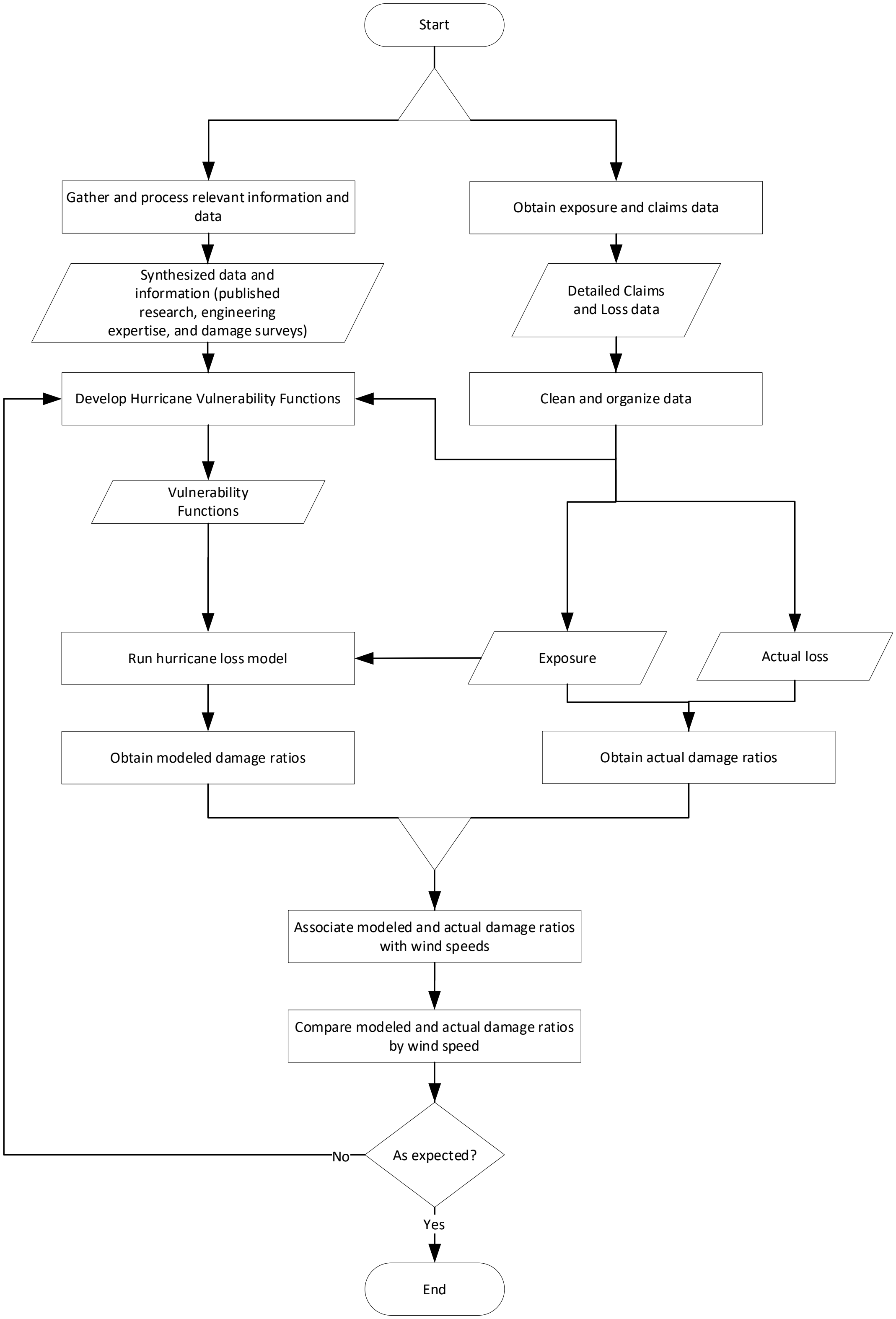


Figure 28. Derivation and Implementation of AIR Vulnerability Functions

3. Describe the nature and extent of actual insurance claims data used to develop the building hurricane vulnerability functions. Describe in detail what is included, such as, number of policies, number of insurers, dates of hurricane loss, amount of hurricane loss, and number of units amount of dollar exposure; separated into personal residential, commercial residential, and manufactured homes.

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. 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. AIR has been provided with detailed data by several client companies covering in excess of $2.5 trillion of personal, $6 billion of manufactured homes, and $75 billion of commercial residential exposure. The cumulative loss across these datasets exceed $45 billion in loss across personal, manufactured homes, and commercial residential lines coming from over 3.3 million claims.

AIR 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 loss data included details by county or state, by line of business, claim counts, 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, AIR 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 AIR after the test. The AIR 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 detailed 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 client company/storm losses have been analyzed. Loss data received from these companies is at the ZIP Code or policy level.

AIR has also received 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. In addition to individual company claims, AIR also obtained industry insured loss estimates from Verisk's Property and Claims Services (PCS) for historical hurricane events, including those that impact Florida. 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 Table 11 below.

Table 11. 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 AIR model vulnerability functions are based on loss data spanning many companies and hurricanes affecting different geographical areas, not Florida exclusively. New data is analyzed as it becomes 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.

4. Describe any new insurance claims datasets collected since the previously-accepted hurricane model.

AIR obtained industry insured loss estimates from Verisk's Property and Claims Services (PCS) for historical hurricane events that have impacted Florida in the years 2017 and 2018. 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 2017 Hurricane Irma and 2018 Hurricane Michael, PCS estimates are available at the county level by the aforementioned lines of business.

5. *Describe the assumptions, data (including insurance claims data), methods, and processes used for the development of the building hurricane vulnerability functions.*

The vulnerability functions developed by AIR 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 AIR'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 is available, the functions are again assessed to ensure a reasonable outcome. Figure 28 in Disclosure V-1.2 shows how the development of the vulnerability model through these components interacts.

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

AIR 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, and most recently, Florence and Michael in 2018. Additionally, AIR 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 AIR'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 AIR 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), AIR engineers validated the effects of wind duration on damage estimation, a fundamental component of the AIR 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.

7. ***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. Provide the total number of building hurricane vulnerability functions available for use in the hurricane model for personal and commercial residential classifications.***

The AIR Hurricane Model for the U.S. 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 9; 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 12, and the modeled height categories are provided in Table 13. The AIR Hurricane Model for the U.S. includes year-built categories: pre-1995, 1995-2001, 2002-2011 and post-2011. Between 1995 and 2015 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 14 lists all the mitigation measures in the AIR Hurricane Model for the U.S.

Table 12. Residential Construction Types in the AIR Hurricane Model for the U.S.

Residential and Apartment or Condominium Buildings	
Construction Type	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

Manufactured Homes	
Construction Type	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 singlewide 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 13. Height Bands for Different Construction Types in the AIR Hurricane Model for the U.S.

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 13). However, AIR 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 9), 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 AIR'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

8. ***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 AIR Hurricane Model for the U.S. considers the regional variation in building codes as explained in Standard V-1.D and Disclosure V.1.7. 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 AIR's secondary risk characteristics (see Appendix 9), in which the users can input detailed building features as appropriate.

9. *Describe the relationship between building structure and appurtenant structure hurricane vulnerability functions and their consistency with insurance 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 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 Disclosure V.1.2.

10. *Describe the assumptions, data (including insurance 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 averaging 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 AIR Hurricane Model for the U.S. supports regional variation in vulnerability when the construction characteristic is unknown. The regional variation is based upon AIR'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 response to Standard V.1.C in this section).

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 9 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 13. In all these cases, the knowledge about the local building inventory which forms the weights for the aforementioned weighted averages is captured in AIR'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 AIR'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 9.

The AIR Hurricane Model for the U.S. 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 AIR's vulnerability classifications, are shown in Table 12. The modeled height categories are shown in Table 13, as described in Disclosure V.1.7. 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 13 ensures that a reasonable damage function, with a logical height, is assigned to the risk.

11. 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.

12. 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 29 illustrates this process.

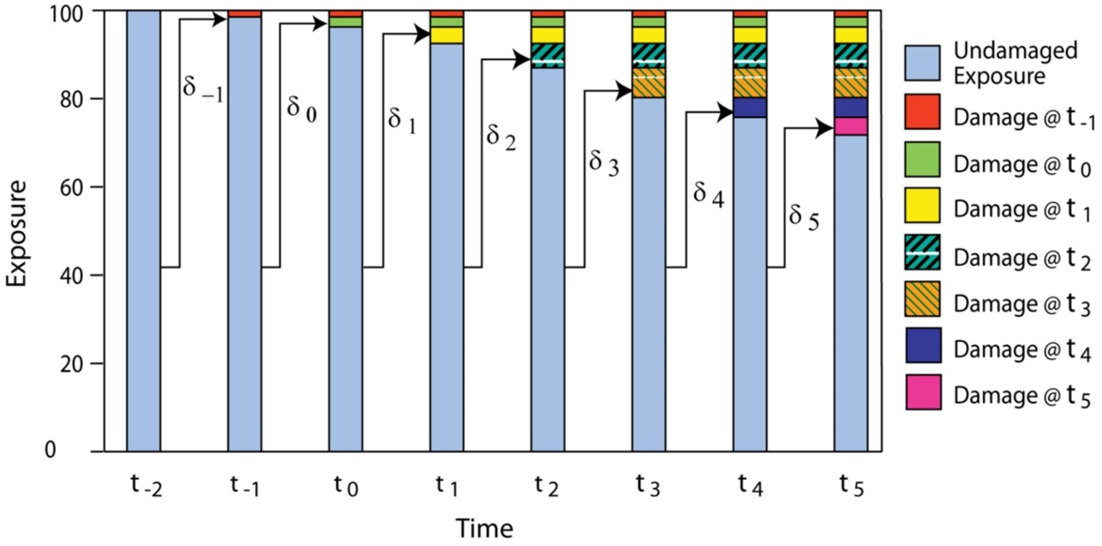


Figure 29. Process of Accounting for the Impact of Wind Duration

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 AIR Hurricane Model for the U.S. considers the complete time profile of wind speeds at each location.

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

The AIR 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 9. Similarly, the ability of a structure to resist water infiltration through various mitigation features can also be captured using secondary characteristic selections.

14. Provide a completed Form V-1, One Hypothetical Event. Provide a link to the location of the form.

Link: Form V-1: One Hypothetical Event

Standard V-2: Derivation of Contents Hurricane Vulnerability Functions

Relevant Forms

- G-4, Vulnerability Standards Expert Certification
- V-1, One Hypothetical Event
- A-1, Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code
- A-6, Logical Relationship to Hurricane Risk (Trade Secret Item)

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

The AIR Hurricane Model for the U.S. 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 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.

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.

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. AIR 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, AIR 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. AIR 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

1. Describe any modifications to the contents vulnerability component in the hurricane model since the previously-accepted hurricane model.

There have been no changes to the contents vulnerability component of personal and commercial residential buildings in the AIR Hurricane Model for the U.S. since the previously accepted model.

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

The process for deriving and implementing the contents vulnerability functions in the AIR Hurricane Model for the U.S. is the same as that used for developing and implementing the building vulnerability functions, as outlined in Disclosure V-1.2.

3. Describe the assumptions, data (including insurance claims data), methods, and processes used to develop and validate the contents hurricane vulnerability functions.

In the AIR Hurricane Model for the U.S., 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.

AIR 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, AIR 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. AIR 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.

4. *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 AIR Hurricane Model for the U.S., 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. 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 V-1.

5. *Describe the relationship between building structure 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 AIR Hurricane Model for the U.S. calculates contents damage separately from building damage.

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

Relevant Forms

- *G-4, Vulnerability Standards Expert Certification*
- *V-1, One Hypothetical Event*
- *A-1, Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code*
- *A-6, Logical Relationship to Hurricane Risk (Trade Secret Item)*

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

The AIR Hurricane Model for the U.S. 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.

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

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. AIR 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. AIR 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.

C. Time element hurricane vulnerability function derivations 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.

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

1. Describe any modifications to the time element vulnerability component in the hurricane model since the previously-accepted hurricane model.

There have been no changes to the time element vulnerability component of personal and commercial residential buildings in the AIR Hurricane Model for the U.S. since the previously accepted model.

2. Provide a flowchart documenting the process by which the time element hurricane vulnerability functions are derived and implemented.

The process for deriving and implementing the time element vulnerability functions in the AIR Hurricane Model for the U.S. is the same as that used for developing and implementing the building vulnerability functions, as outlined in Disclosure V-1.2.

3. Describe the assumptions, data, methods, and processes used to develop and validate 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.

AIR 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, AIR 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. AIR 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.

4. *Describe how time element hurricane vulnerability functions take into consideration the damage (including damage due to flood, (including hurricane storm surge), and wind) to local and regional infrastructure.*

Time element losses are calculated independently for the wind and storm surge perils in the AIR Hurricane Model for the U.S. Model users can choose to include, exclude, or include a portion of the losses from storm surge in the reported time element loss estimates. No storm surge losses for time element coverage are included in the submitted loss costs. The AIR Hurricane Model for the U.S. does not explicitly estimate losses from precipitation induced flood damage.

AIR 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 AIR vulnerability functions within the development, calibration, and validation. Thus, modeled time element losses implicitly take into consideration damage to local and regional infrastructure.

5. *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

Relevant Forms

- *G-4, Vulnerability Standards Expert Certification*
- *V-2, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage*
- *V-3, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item)*
- *V-4, Differences in Hurricane Mitigation Measures and Secondary Characteristics*
- *V-5, Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item)*
- *A-6, Logical Relationship to Hurricane Risk (Trade Secret Item)*

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

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

The secondary risk characteristics, a part of AIR's Individual Risk Model documented in Appendix 9, 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 AIR Hurricane Model for the U.S. 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 9, are theoretically sound. Disclosure V-4.7 provides an understanding of the treatment of uncertainty in AIR's Hurricane Model for the U.S.

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 AIR Hurricane Model for the U.S. 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.

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 9.

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

AIR's 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.

AIR's 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 AIR 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 9.

Disclosures

1. *Describe any modifications to hurricane mitigation measures and secondary characteristics in the hurricane model since the previously-accepted hurricane model.*

The implementation of the "roof year built" secondary risk feature has been updated to default to a new roof for those structures that are built within the last ten years, current as of 2020. In addition to this, the logic of roof age assignment has been updated to assign buildings built within the last 10–20 years to have an "average" roof year built when the roof year built is unknown.

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 previously-accepted hurricane model.*

The Individual Risk Module described in Appendix 9 has been implemented as a part of the AIR Hurricane Model for the U.S. V1.0.0 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 2020. This software has been modified to account for the items described in Disclosure V-4.1.

3. *Provide a completed Form V-2, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage. Provide a link to the location of the form.*

A completed Form V-2 is provided in Excel format and linked here: 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, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage.*

Table 14 includes all mitigation measures and secondary characteristics that are available in the AIR Hurricane Model for the U.S.

Table 14. Mitigation Measures and Secondary Characteristics in the AIR Hurricane Model for the U.S.

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
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

Mitigation Measures	Description
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.

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

AIR’s 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 14 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. AIR’s 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 9 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 1.00, 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.

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.

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. AIR's 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 14 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 AIR 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.

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

The AIR 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.

9. ***Provide a completed Form V-3, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), if not considered as Trade Secret. Provide a link to the location of the form.***

Form V-3 is considered a trade secret item and will be presented to the Professional Team and at the closed meeting of the Commission for review.

10. ***Provide a completed Form V-4, Differences in Hurricane Mitigation Measures and Secondary Characteristics. Provide a link to the location of the form.***

A completed Form V-4 is provided in Excel format, and is linked here: Form V-4: Differences in Hurricane Mitigation Measures and Secondary Characteristics.

11. ***Provide a completed Form V-5, Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), if not considered as Trade Secret. Provide a link to the location of the form.***

Form V-5 is considered a trade secret item and will be presented to the Professional Team and at the closed meeting of the Commission for review.

Actuarial Standards

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

Relevant Form

- *G-5, Actuarial Standards Expert Certification*

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 is 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 Disclosure 3 through Disclosure 6 and the Touchstone Validation Reference.

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 is 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 at https://unicede.air-worldwide.com/ts_val-ref_intro/unicede-val-ref.html .

Upon import, Touchstone validates the data provided. If there is insufficient data provided by the user, 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

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 assumptions to the input data if they are aware that insurance-to-value issues exist in their book.

Table 15. Sample Calculation for Adjusting Input Values for ITV Assumptions

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

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

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 16. Sample Calculation for Determining ACV Losses*

	Actual
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

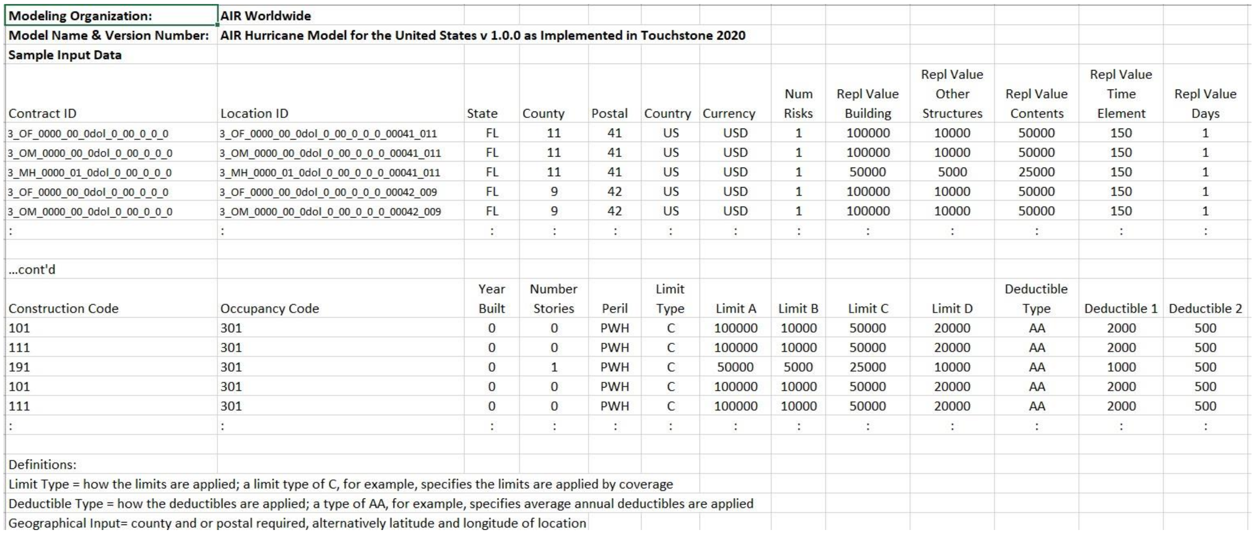
3. *Describe the methods used to distinguish among policy form types (e.g., homeowners, dwelling property, manufactured homes, tenants, condo unit owners).*

The AIR Hurricane Model for the U.S. 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 coverage A, B, C, and D or any combination. The model can produce loss costs for defined groups of policies if vulnerability characteristics are known. Such characteristics are described in Standard V-1: Derivation of Building Hurricane Vulnerability Functions.

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 submitted to the Commission shall be clearly labeled and defined.*

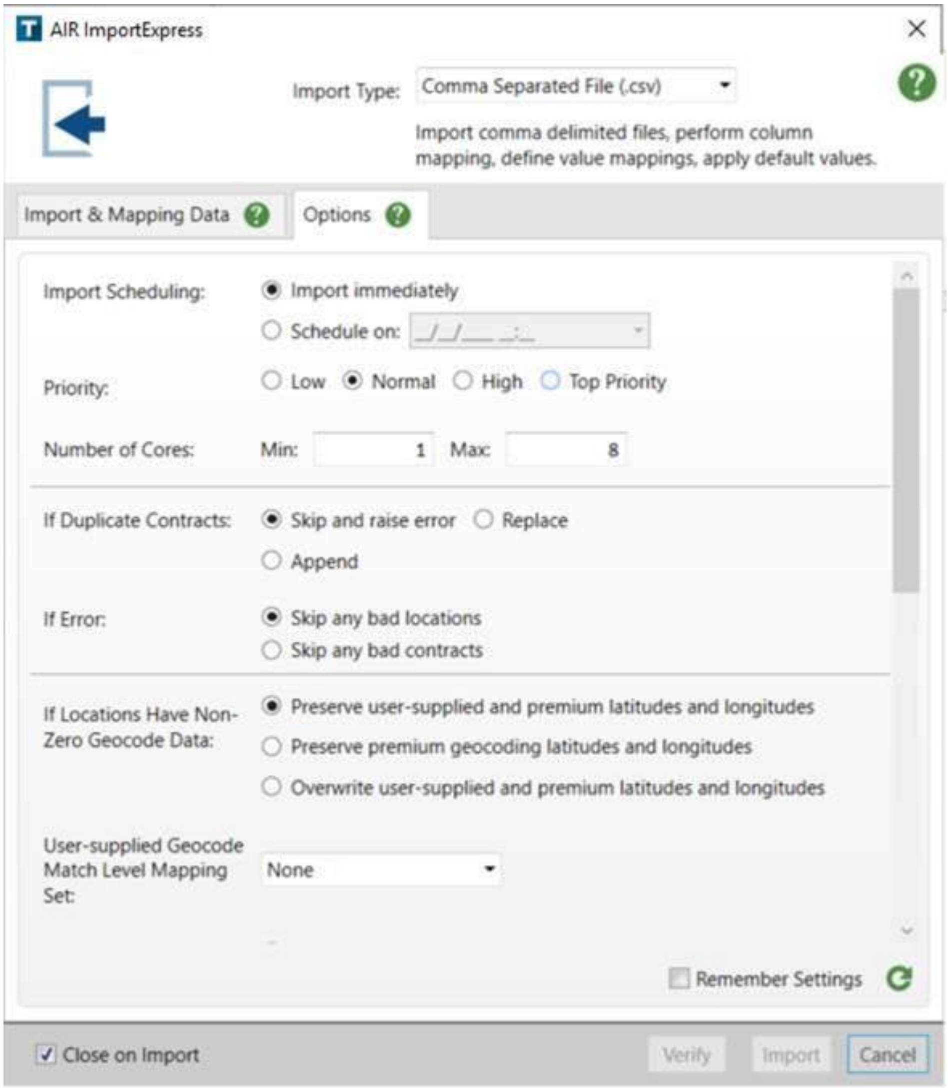
There is no single required input form for exposure data being imported into the software. It is flexible enough to handle many types of input formats. Comma Separated Value (.csv) files are commonly used to import data into Touchstone. The Import section of the Touchstone Online Help describes the format 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 30. During the import process, the user can set default import assumptions, shown in Figure 31.



Modeling Organization:	**AIR Worldwide**											
Model Name & Version Number:	**AIR Hurricane Model for the United States v 1.0.0 as Implemented in Touchstone 2020**											
Sample Input Data												
Contract ID	Location ID	State	County	Postal	Country	Currency	Num Risks	Repl Value Building	Repl Value Other Structures	Repl Value Contents	Repl Value Time Element	Repl Value Days
3_OF_0000_00_0dol_0_00_0_0_0	3_OF_0000_00_0dol_0_00_0_0_0_00041_011	FL	11	41	US	USD	1	100000	10000	50000	150	1
3_OM_0000_00_0dol_0_00_0_0_0	3_OM_0000_00_0dol_0_00_0_0_0_00041_011	FL	11	41	US	USD	1	100000	10000	50000	150	1
3_MH_0000_01_0dol_0_00_0_0_0	3_MH_0000_01_0dol_0_00_0_0_0_00041_011	FL	11	41	US	USD	1	50000	5000	25000	150	1
3_OF_0000_00_0dol_0_00_0_0_0	3_OF_0000_00_0dol_0_00_0_0_0_00042_009	FL	9	42	US	USD	1	100000	10000	50000	150	1
3_OM_0000_00_0dol_0_00_0_0_0	3_OM_0000_00_0dol_0_00_0_0_0_00042_009	FL	9	42	US	USD	1	100000	10000	50000	150	1
:	:	:	:	:	:	:	:	:	:	:	:	:
...cont'd												
Construction Code	Occupancy Code	Year Built	Number Stories	Peril	Limit Type	Limit A	Limit B	Limit C	Limit D	Deductible Type	Deductible 1	Deductible 2
101	301	0	0	PWH	C	100000	10000	50000	20000	AA	2000	500
111	301	0	0	PWH	C	100000	10000	50000	20000	AA	2000	500
191	301	0	1	PWH	C	50000	5000	25000	10000	AA	1000	500
101	301	0	0	PWH	C	100000	10000	50000	20000	AA	2000	500
111	301	0	0	PWH	C	100000	10000	50000	20000	AA	2000	500
:	:	:	:	:	:	:	:	:	:	:	:	:
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 30. Sample Input File



Import Type: Comma Separated File (.csv)

Import comma delimited files, perform column mapping, define value mappings, apply default values.

Import Scheduling: ● Import immediately ○ Schedule on: _/_/___ _:_

Priority: ○ Low ● Normal ○ High ○ Top Priority

Number of Cores: Min: 1 Max: 8

If Duplicate Contracts: ● Skip and raise error ○ Replace ○ Append

If Error: ● Skip any bad locations ○ Skip any bad contracts

If Locations Have Non-Zero Geocode Data: ● Preserve user-supplied and premium latitudes and longitudes ○ Preserve premium geocoding latitudes and longitudes ○ Overwrite user-supplied and premium latitudes and longitudes

User-supplied Geocode Match Level Mapping Set: None

☐ Remember Settings

☑ Close on Import

Figure 31. Model Input Options

The process followed by the user to generate the model output produced by such input is shown in Figure 32.

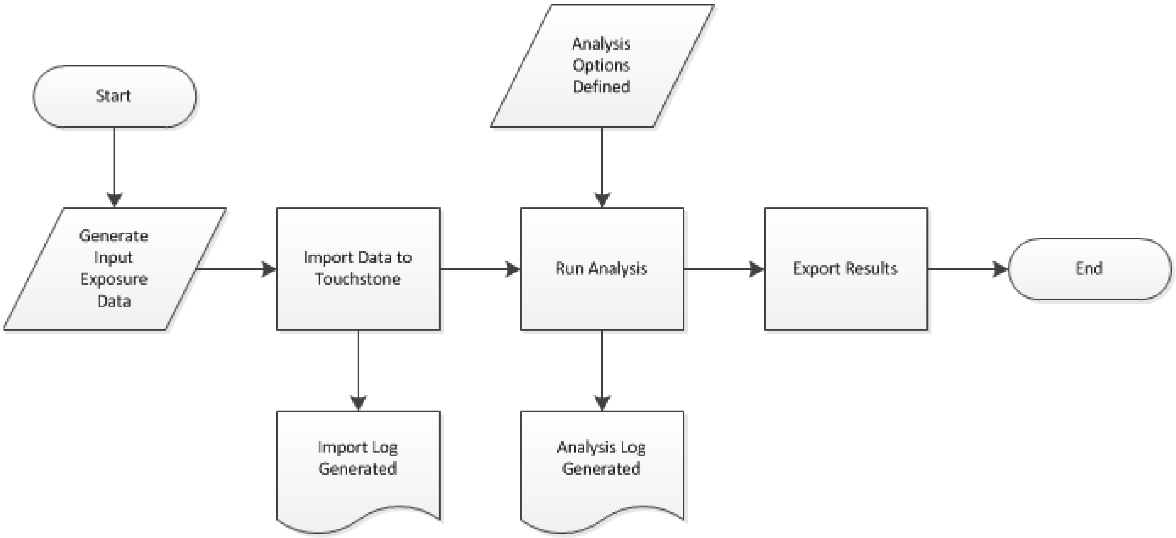
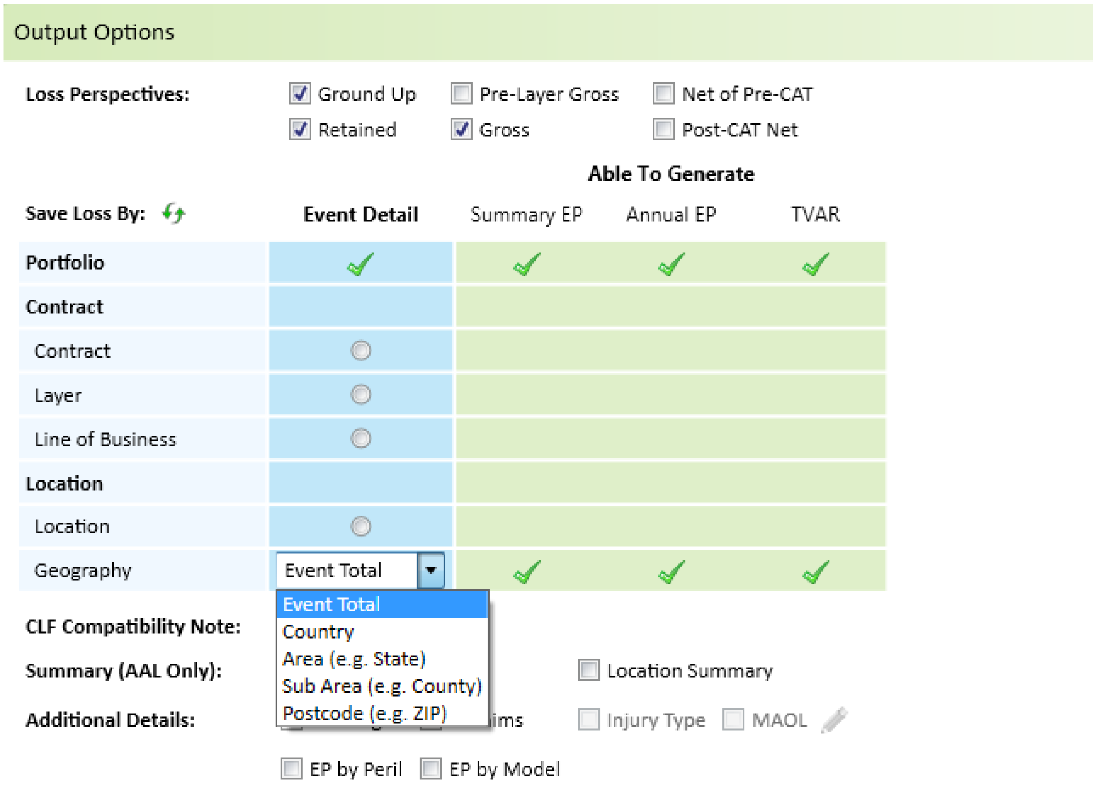


Figure 32. Process to create Model Output

Figure 33 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. All settings chosen by the user are reported in the analysis log. A sample analysis is included in Appendix 6: Model Output Forms.


Output Options

Loss Perspectives: ☑ Ground Up ☐ Pre-Layer Gross ☐ Net of Pre-CAT
☑ Retained ☑ Gross ☐ Post-CAT Net

Save Loss By:	Event Detail	Able To Generate		
		Summary EP	Annual EP	TVAR
Portfolio	✓	✓	✓	✓
Contract				
Contract	○			
Layer	○			
Line of Business	○			
Location				
Location	○			
Geography	Event Total ▾	✓	✓	✓

CLF Compatibility Note:

Summary (AAL Only): ☐ Location Summary

Additional Details: ims ☐ Injury Type ☐ MAOL

☐ EP by Peril ☐ EP by Model

Figure 33. Output Options Dialog Box Displayed in the Touchstone User Interface

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. 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 submitted to the Commission shall be clearly labeled and defined.***

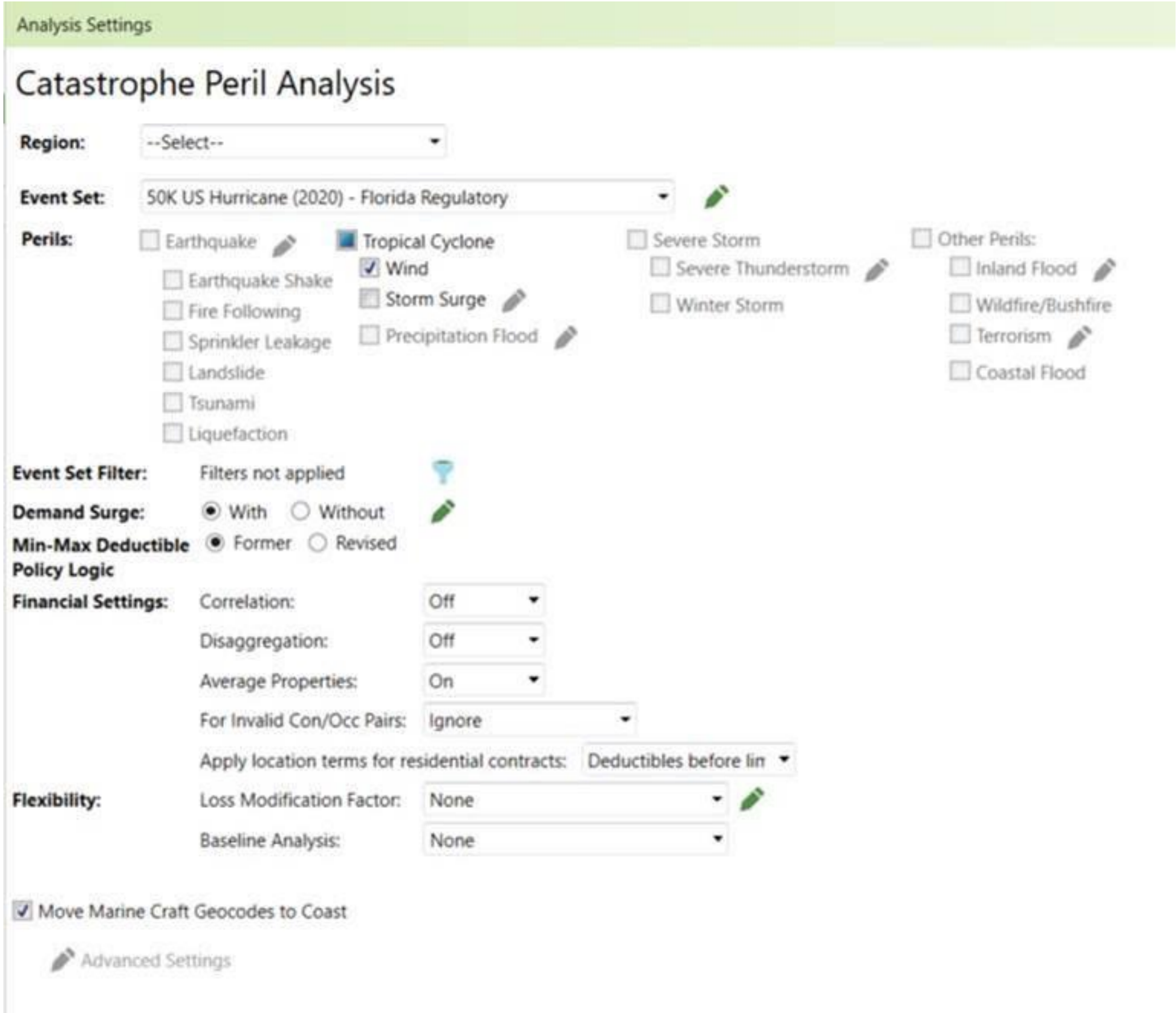
In addition to the input exposure data, the user must define specific inputs (or analysis options) in order to run a catastrophe loss analysis. These inputs are disclosed in Touchstone's output report or analysis log, a sample of which is included in Appendix 6: Model Output Forms

As a user initiates an analysis in Touchstone, they must customize their analysis options. Analysis options govern which settings are turned on and off for a particular analysis. Certain analysis options affect the resulting loss estimates in Florida, while others do not. AIR has identified the following analysis options as required for rate making in Florida. Table 17 is divided into two parts: required and optional analysis settings. AIR recommends the required settings to be used, while optional settings may be customized by the user depending on their portfolio and reporting needs.

Table 17. Catastrophe Peril Analysis Options Applicable for Florida Rate Making

Analysis Option	Setting	Notes
Required Settings		
Event Set	50K US Hurricane (2020) – Florida Regulatory	The event sets that are included in the list depend on the countries and perils licensed. The 50k or 100k Standard event set must be used.
Peril	Only check Tropical Cyclone - Wind	Losses from wind are covered by residential policies. Storm surge losses must be excluded. Storm surge is an abnormal rise in sea level accompanying a hurricane or other storm. Users can include an estimate of the separately modeled storm surge losses when calculating losses for tropical cyclone events. When the storm surge peril box is unchecked, the model will only report wind modeled losses, and exclude storm surge losses.
Demand Surge	With	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. Touchstone comes with a standard demand surge curve for the U.S.
Correlation	Off	The correlation analysis option allows users to choose to apply correlation factors between loss distributions during an analysis. This option generally applies in the case of multi-contract or multi-location commercial policies.
Flexibility Option (a.k.a. Loss Modification Factor)	None (displayed in Analysis Log as "Not Available")	Touchstone allows users to apply a loss modification factor directly to ground-up losses that AIR models produce. This function enables users to perform sensitivity analyses on potential portfolio losses. Selecting None will produce only the AIR default loss perspective; therefore this is the required setting for any Florida rate filing analyses.

Analysis Option	**Setting**	**Notes**
Event Set Filter	Do Not Apply	Applying an event set filter enables a user to run a standard loss analysis for a user-defined subset of events in the selected event set. For rate filing in Florida, no event set filters should be applied
Optional Settings		
Average Properties	Automatic, On or Off	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.
Apply Location Terms for Residential Contracts	Use AIR option for Deductibles Before Limit	The model allows the user to model losses with two options: Limits Before Deductible (model default) and Deductible Before Limits. We actively advise clients to select the Deductible Before Limits option, which applies the limit after the deductible.
Disaggregation	On or Off	When enabled, 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 AIR's Industry Exposure Database. This process enables Touchstone 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 Touchstone document Exposure Disaggregation in Touchstone.
Min-Max Deductible Policy Logic	Former or revised	This analysis option is not applicable to residential policies. This feature enhances the loss calculation for layers that have a min/max deductible and have sublimits on that layer. This structure is most common to complex commercial policies. In summary, the updated algorithm more accurately represents the order of application of location limits and sublimits 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 policy deductible scenario is selected with the radio buttons by the user.



Analysis Settings

Catastrophe Peril Analysis

Region: --Select--

Event Set: 50K US Hurricane (2020) - Florida Regulatory

Perils:
- ☐ Earthquake
  - ☐ Earthquake Shake
  - ☐ Fire Following
  - ☐ Sprinkler Leakage
  - ☐ Landslide
  - ☐ Tsunami
  - ☐ Liquefaction
- ▣ Tropical Cyclone
  - ☑ Wind
  - ☐ Storm Surge
  - ☐ Precipitation Flood
- ☐ Severe Storm
  - ☐ Severe Thunderstorm
  - ☐ Winter Storm
- ☐ Other Perils:
  - ☐ Inland Flood
  - ☐ Wildfire/Bushfire
  - ☐ Terrorism
  - ☐ Coastal Flood

Event Set Filter: Filters not applied

Demand Surge: ● With ○ Without

Min-Max Deductible Policy Logic: ● Former ○ Revised

Financial Settings:
- Correlation: Off
- Disaggregation: Off
- Average Properties: On
- For Invalid Con/Occ Pairs: Ignore
- Apply location terms for residential contracts: Deductibles before lin

Flexibility:
- Loss Modification Factor: None
- Baseline Analysis: None

☑ Move Marine Craft Geocodes to Coast

Figure 34. Catastrophe Peril Analysis Dialog Box Displayed in the Touchstone User Interface

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

Touchstone applies validation rules during exposure data import, as well as within the exposure-related portions of the Touchstone user interface. When a validation error occurs, Touchstone 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. AIR's Touchstone Exposure Data Validation Reference on the https://unicede.air-worldwide.com/ts_val-ref_intro/unicede-val-ref.html website contains documentation for the extensive validations performed to ensure the validity of insurer or other input data used for modeling.

7. 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.

8. Disclose if removing and 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, Retained (by insured), or Gross (net of policy terms) loss analysis results. Net of Pre-Cat and Post-Cat Net results may be impacted through the impact of reinsurance treaties which depend on losses for the portfolio as a whole or the aggregation of losses over a certain threshold.

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

Relevant Forms

- G-5, Actuarial Standards Expert Certification
- A-2, Base Hurricane Storm Set Statewide 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.

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 1 also supports compliance with Standard A.2.A.

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

The AIR Hurricane Model for the United States provides the user the ability to select specified perils for each analysis. This is shown in Figure 34 Specific peril losses are calculated independently in the model. Information about estimation of specific peril losses is included in the model documentation. The analysis log produced when the user runs the model also contains peril specific details of the analysis. Disclosure 2 also supports compliance with Standard A.2.B.

Disclosures

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 17 that make landfall in Florida or are Florida bypassers. 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.

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.*

AIR’s Hurricane Model for the U.S. contains the perils of wind and storm surge flooding. Fluvial and pluvial flooding from hurricane induced precipitation is not included in the Hurricane Model for the U.S. being submitted at this time. Further, the peril of flooding from non-hurricane sources including tropical storms, severe convective storms, to mention a few, is not included in the Hurricane Model for the U.S. but is included in a separate model called the Inland Flood Model for the U.S.

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 have the option to exclude storm surge losses in the modeled loss estimates, loss costs, and hurricane probable maximum loss levels, or to enter a percentage (0% to 100%) of storm surge losses to include. For purposes of this submission, surge losses were completely excluded from the reported results.

Standard A-3: Hurricane Coverages

Relevant Form

- *G-5, Actuarial Standards Expert Certification*

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

The AIR Hurricane Model for the U.S. represents losses to building coverage separately from contents, and appurtenant structures and time element. The methods used in the calculation of building coverage loss costs are actuarially sound. This method is described in detail in Disclosure 1 of this standard.

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

The AIR Hurricane Model for the U.S. 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 2 below.

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

The AIR Hurricane Model for the U.S. 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. Please see Disclosure 3 for a description.

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

The AIR Hurricane Model for the U.S. represents losses to time element (also referred to as Additional Living Expense, or “ALE”) coverage separately from building, contents, and appurtenant structures. The methods used in the calculation of time element coverage loss costs are actuarially sound. Please see Disclosure 4 for a description.

Disclosures

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. 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.

AIR'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.

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 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.

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 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.

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 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.

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 1 and the Damage Estimation Overview section of Appendix 9, 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 to have 100% damage at any wind speed. Additionally, this probability distribution is constructed in such a way as to assign 100% structural damage (i.e. complete replacement) to structures which have a high level (not 100%) 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

Relevant Forms

- *G-5, Actuarial Standards Expert Certification*
- *A-8, Hurricane Probable Maximum Loss for Florida*

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 AIR Hurricane Model for the U.S. 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 30. 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 1 through 4 of Standard A-3.

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 to 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 values to estimate hurricane losses and probable maximum losses without adjustment.

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).

Hurricane model users have the option to include, exclude or include only a percentage of the surge losses including direct flood losses along with wind losses in the reported loss estimates. For this submission, hurricane modeled loss costs and hurricane probable maximum loss levels do not include any explicit provision for direct flood losses including those from hurricane storm surge losses.

Model users have the option to exclude storm surge losses in the modeled loss estimates, loss costs, and hurricane probable maximum loss levels, or to enter a percentage (0% to 100%) of storm surge losses to include. Other sources of direct flood loss are not included in the Hurricane Model for the U.S. For purposes of this submission, surge losses were completely excluded from the reported results.

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

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 form above in Standard A-1 Disclosure 4 and the Touchstone Validation Reference. More information is also included in Disclosure 2 below.

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 AIR'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"). AIR's demand surge function has been developed using relevant data and actuarially sound methods and assumptions. Additional information on AIR's demand surge function is included in Disclosures 3 and 4 below.

Disclosures

1. Describe the method(s) used to estimate annual hurricane loss costs and hurricane probable maximum loss levels and their 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 our 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 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 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.

2. ***Identify the highest level of resolution for which hurricane loss costs and hurricane probable maximum loss levels can be provided. Identify all possible resolutions available for the reported hurricane output ranges.***

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). The reported output ranges in this submission (Form A-4: Hurricane Output Ranges) use 5-digit ZIP Code resolution. 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.

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, even taking into account some buffer. 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

AIR 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.

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. AIR 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.

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

Relevant Form

- *G-5, Actuarial Standards Expert Certification*
- *A-4, Hurricane Output Ranges*
- *A-6, Logical Relationship to Hurricane Risk (Trade Secret Item)*

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 AIR 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 35.

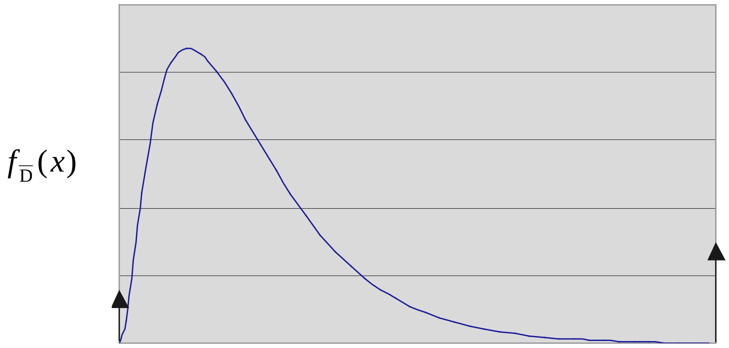


Figure 35. Probability Distribution Around the Mean Damage Ratio

Thus, the effects of deductibles, coinsurance and other policy conditions can be properly calculated, as this sample insured loss calculation illustrates:

$$= \int_{x=0}^{1} f_{\bar{D}}(x)\,[\mathrm{Coins\%} * (\min(\mathrm{PL}, \max(0, \mathrm{x} * \mathrm{RV} - \mathrm{DED}))]\,dx$$

where

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, Touchstone does apply demand surge to the ground up losses. In application, $f_{\bar{D}}(x)$ is discretized and numerical integration is used to estimate the expected insured loss.

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 do decrease as deductibles increase, other factors held constant. This is clearly demonstrated in the deductible section of trade secret Form A-6 deductibles, which will be shown to the professional team during audit.

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

The AIR Hurricane Model for the U.S. 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 the all other perils deductible to losses from subsequent events in the same calendar year. Additional detail is included in Disclosure 3 below.

Disclosures

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 A-1, Disclosure 1.

2. Describe whether, and if so how, the hurricane model treats policy exclusions and loss settlement provisions.

Policy exclusions, with the exception of exclusions for flood, and loss settlement provisions are implicitly factored into the hurricane model as much 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 and may be accounted for in other modeled perils.

3. Describe how the hurricane model treats annual deductibles.

Annual frequency of hurricane event occurrence is a key hurricane model parameter. Each simulated year may have zero, one, or multiple events. This approach for generating the event catalog makes it straightforward to determine the probability and losses of multiple-event seasons.

The functionality to calculate losses net of an annual deductible was enabled during 2005 in the software. Prior to this, the user would have performed the calculations outside the software. The deductible is applied in Touchstone as follows: 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.

Applicable Deductible = Σ min(loss, deductible)*probability,

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.

Example: User enters $10,000 as the hurricane deductible (DED1) and $500 as the all other perils deductible (DED2). Suppose a first event occurs with a loss of $7,000, and the applicable deductible is calculated as $7,000, with a remaining deductible of $3,000. Note that for the next event in the same year, the deductible will be max ($3,000, $500), or $3,000.

Suppose a second event occurs in the year, and the applicable deductible is calculated as $2,700. The remaining hurricane deductible is max ($300, $500), or $500. In other words, from this point on, the $500 all other perils deductible would apply to each subsequent event in the year.

One final note: the application of the all other perils deductible only applies to years when there are multiple events—the full hurricane deductible of $10,000 will apply if there is only a single event in a given year.

Standard A-6: Hurricane Loss Output and Logical Relationships to Risk

Relevant Form

- G-5, Actuarial Standards Expert Certification
- A-1, Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code
- A-2, Base Hurricane Storm Set Statewide Hurricane Losses
- A-3, Hurricane Losses
- A-4, Hurricane Output Ranges
- A-5, Percentage Change in Hurricane Output Ranges
- A-6, Logical Relationship to Hurricane Risk (Trade Secret Item)
- A-7, Percentage Change in Logical Relationship to Hurricane Risk
- A-8, Hurricane Probable Maximum Loss for Florida
- S-2, Examples of Hurricane Loss Exceedance Estimates
- S-5, Average Annual Zero Deductible Statewide Hurricane Loss Costs – Historical versus Modeled

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 AIR Hurricane Model for the U.S. uses actuarially sound methods, data and assumptions in the estimation of hurricane probable maximum loss levels. The AIR method of estimating is described in detail in Standard A-4 Disclosure 1 and referenced in the actuarial literature.

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 AIR Hurricane Model for the U.S. 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 demonstrate this. Form A-6 will be available on-site for the Professional Team’s review.

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 clearly displays that the model produces non-zero loss costs for all postal codes in the state.

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, and demonstrate that loss costs do not increase as the quality of construction and materials increase. Masonry loss costs are lower than frame loss costs all else equal and frame loss costs are lower than manufactured home loss costs at each location. Further, hurricane loss cost sensitivity tests performed in Form A-6 demonstrate this. Form A-6 will be available on-site for the Professional Team’s review.

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 Relationship to Hurricane Risk, demonstrate this. Form A-6 will be available on-site for the Professional Team’s review.

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 demonstrate this. Form A-6 will be available on-site for the Professional Team’s review.

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 demonstrate this. Form A-6 will be available on-site for the Professional Team’s review.

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 demonstrate this. Form A-6 will be available on-site for the Professional Team’s review.

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 demonstrate this. Form A-6 will be available on-site for the Professional Team's review.

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, and demonstrate 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 14 below.

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 Relationship to Hurricane Risk (Trade Secret Item), hurricane output ranges produced by the AIR hurricane model reflect lower hurricane loss costs for the modeled factors in Disclosure K 1-5 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 is a trade secret item, and will be available on-site for the Professional Team's review.

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.

AIR uses historical insured hurricane losses received from clients for validation purposes. This loss data typically includes both exposure and loss details including construction characteristics and policy provisions such as coverage and deductible. The flow chart in Figure 36 demonstrates the workflow associated with receiving, validating and using client data.

AIR 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.

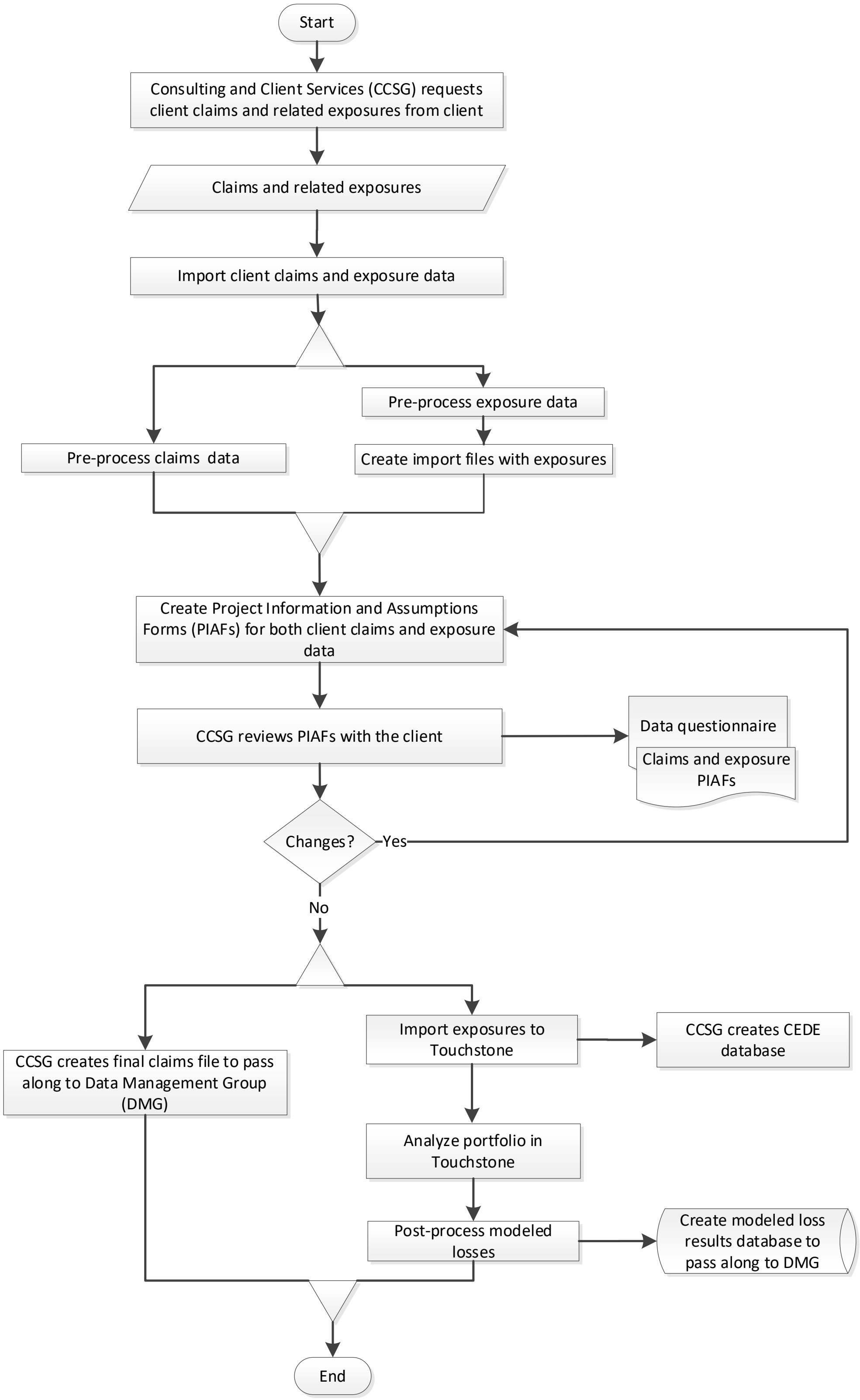


Figure 36. Historical Claims Data Workflow

Disclosures

1. ***Provide a completed Form A-1, Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code. Provide a link to the location of the form.***

Link: Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

A completed Form A-1 is also provided in both Excel and PDF formats in the files named “AIR19FormA1”.

2. ***Provide a completed Form A-2, Base Hurricane Storm Set Statewide Hurricane Losses. Provide a link to the location of the form.***

Link: Form A-2: Base Hurricane Storm Set Statewide Hurricane Losses

3. ***Provide a completed Form A-3, Hurricane Losses. Provide a link to the location of the form.***

Link: Form A-3: Hurricane Losses

4. ***Provide a completed Form A-4, Hurricane Output Ranges. Provide a link to the location of the form.***

Link: Form A-4: Hurricane Output Ranges

5. ***Provide a completed Form A-5, Percentage Change in Hurricane Output Ranges. Provide a link to the location of the form.***

Link: Form A-5: Percentage Change in Hurricane Output Ranges

6. ***Provide a completed Form A-6, Logical Relationship to Hurricane Risk (Trade Secret Item), if not considered as Trade Secret. Provide a link to the location of the form.***

This trade secret will be made available to the Professional Team at the time of the audit.

7. ***Provide a completed Form A-7, Percentage Change in Logical Relationship to Hurricane Risk. Provide a link to the location of the form.***

Link: Form A-7: Percentage Change in Logical Relationship to Hurricane Risk

8. *Explain any assumptions, deviations, and differences from the prescribed exposure information in Form A-6, Logical Relationship to Hurricane Risk (Trade Secret Item), and Form A-7, Percentage Change in Logical Relationship to Hurricane Risk. In particular, explain how the treatment of unknown is handled in each sensitivity exhibit.*

AIR did not deviate from the prescribed exposure information in Forms A-6 or A-7. When the prescribed data included unknown values, these values assumed the model default indications. A detailed explanation of how the AIR model handles unknown values is included in Standard V-1 Disclosure 9.

9. *Provide a completed Form A-8, Hurricane Probable Maximum Loss for Florida. Provide a link to the location of the form.*

Link: Form A-8: Hurricane Probable Maximum Loss for Florida

10. *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 A-4, Disclosure 1.

11. *Provide citations to published papers, 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 (PML). Standard probability theory supports AIR’s event-ranking methodology for assembling PMLs.

12. *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 A-4, Disclosure 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 A-1, Disclosure 3.

13. *Explain any differences between the values provided on Form A-8, Hurricane Probable Maximum Loss for Florida, and those provided on Form S-2, Examples of Hurricane Loss Exceedance Estimates.*

There are no differences between the values provided on Form A-8.B and those provided on Form S-2.B.

14. *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 18. 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.	Construction		
	Masonry		3.73
	Frame		2.27

Anomalies of this type have been background-shaded in orange in Form A-4: Hurricane Output Ranges.

15. *Provide an explanation of the differences in hurricane output ranges between the previously-accepted hurricane model and the current hurricane model.*

The differences in the output between the prior year and the current year submission are due to the hurricane model updates described in G-1, Disclosure 7.

16. *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 through the use of 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.

Forms included in Appendix 5: Actuarial Standards.

Computer/Information Standards

Standard CI-1: Hurricane Model Documentation

Relevant Form

- G-6, Computer/Information Standards Expert Certification

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

AIR Worldwide 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 shall be available for review by the independent peer auditor and by the Professional Team.

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

AIR Worldwide 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 AIR Intranet (AIRPort) by internal users is validated by Windows®-authenticated user name and password. The client-based documentation, available via the Client Portal and Developer’s Zone sites on the AIR public website, 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 are available to clients from the Client Portal site of the AIR public website.
- API documentation is presented as an HTML web-based documentation set. This documentation set is available to clients from the Developer’s Zone site of the AIR public website. This documentation is also available in PDF format.
- Database documentation is presented as an HTML, web-based documentation set. This documentation set is available to clients from the Developer’s Zone site of the AIR public website. This documentation is also available in PDF format.
- Topic-based User Help system, which is available to the user via the software application.

The internal documentation, which is available to AIR employees via AIRPort, includes:

- Documentation types include, but are not limited to, requirements, user stories, design documents, architecture documents, test plans, and project schedules.
- Help system, which presents model and software topics.
- Documentation that provides detailed discussion regarding the development of the model and software. This documentation is available from a designated FCHLPM documentation repository on AIRPort.

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.

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

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.

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

The document *Enhancements and Florida Commission Documentation Mapping* identifies the updates specific to the current version of the AIR Hurricane Model for the U.S. and Touchstone 2020 as required to satisfy General Standard G-1, Disclosure item 7, as well as the changes from the previously accepted submission.

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

The AIR Hurricane Model for the U.S. 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.

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 *List of All Externally-Acquired 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 AIR Worldwide. This spreadsheet is available for review by the independent peer auditor and by the Professional Team.

Standard CI-2: Hurricane Model Requirements

Relevant Form

- *G-6, Computer/Information Standards Expert Certification*

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 AIR Hurricane Model for the U.S. 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 AIRPort, includes the following information:

- Motivation for update
- Model Updates – Specification/Impact
- Software Updates – Specification/Impact

The workflow in Figure 37 illustrates the Requirements development and review process.

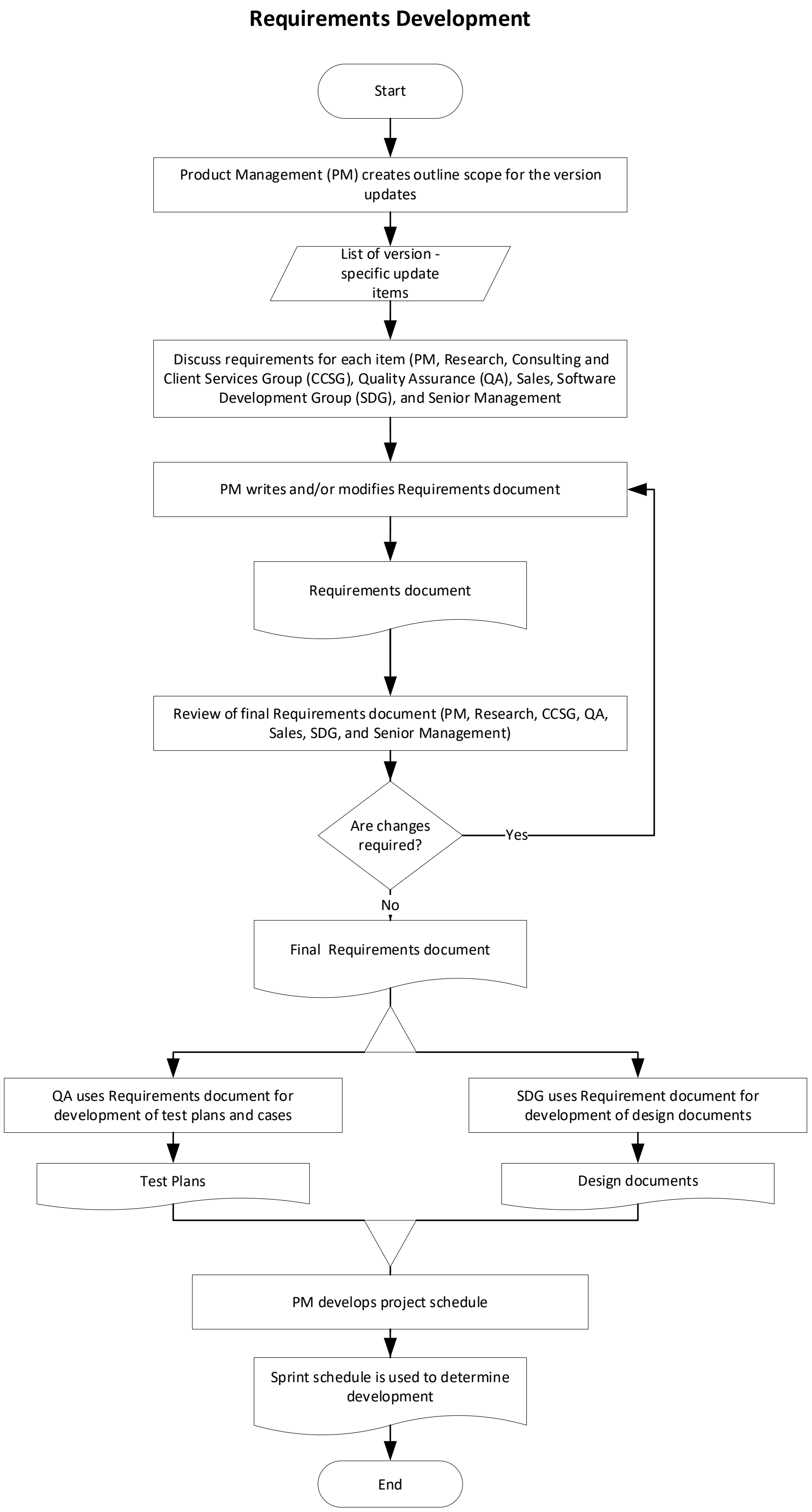


Figure 37. Requirements Development and Review Process

Disclosures

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. AIR 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 AIR Hurricane Model for the U.S. in Touchstone*). These documents are available to clients via the Client Portal site on the AIR public website.

The AIR Hurricane Model for the U.S. 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 AIR client portal www.air-worldwide.com after login.

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 of the AIR public website. This documentation is also available in PDF.

Standard CI-3: Hurricane Model Organization and Component Design

Relevant Form

- G-6, Computer/Information Standards Expert Certification

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 AIR Hurricane Model for the U.S. 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 AIR 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 AIR Hurricane Model for the U.S. 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 the following figure:

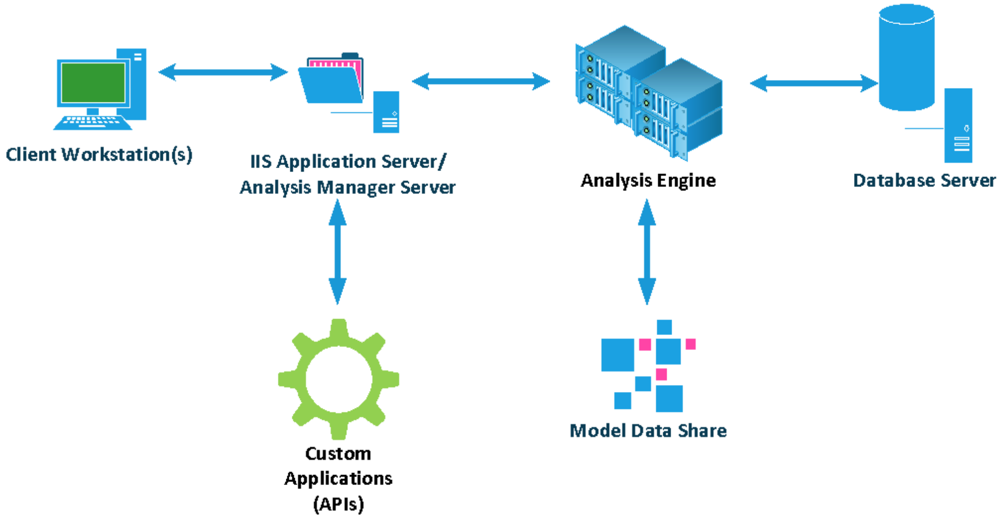


Figure 38. Touchstone Network Layout

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 39 to Figure 47 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.

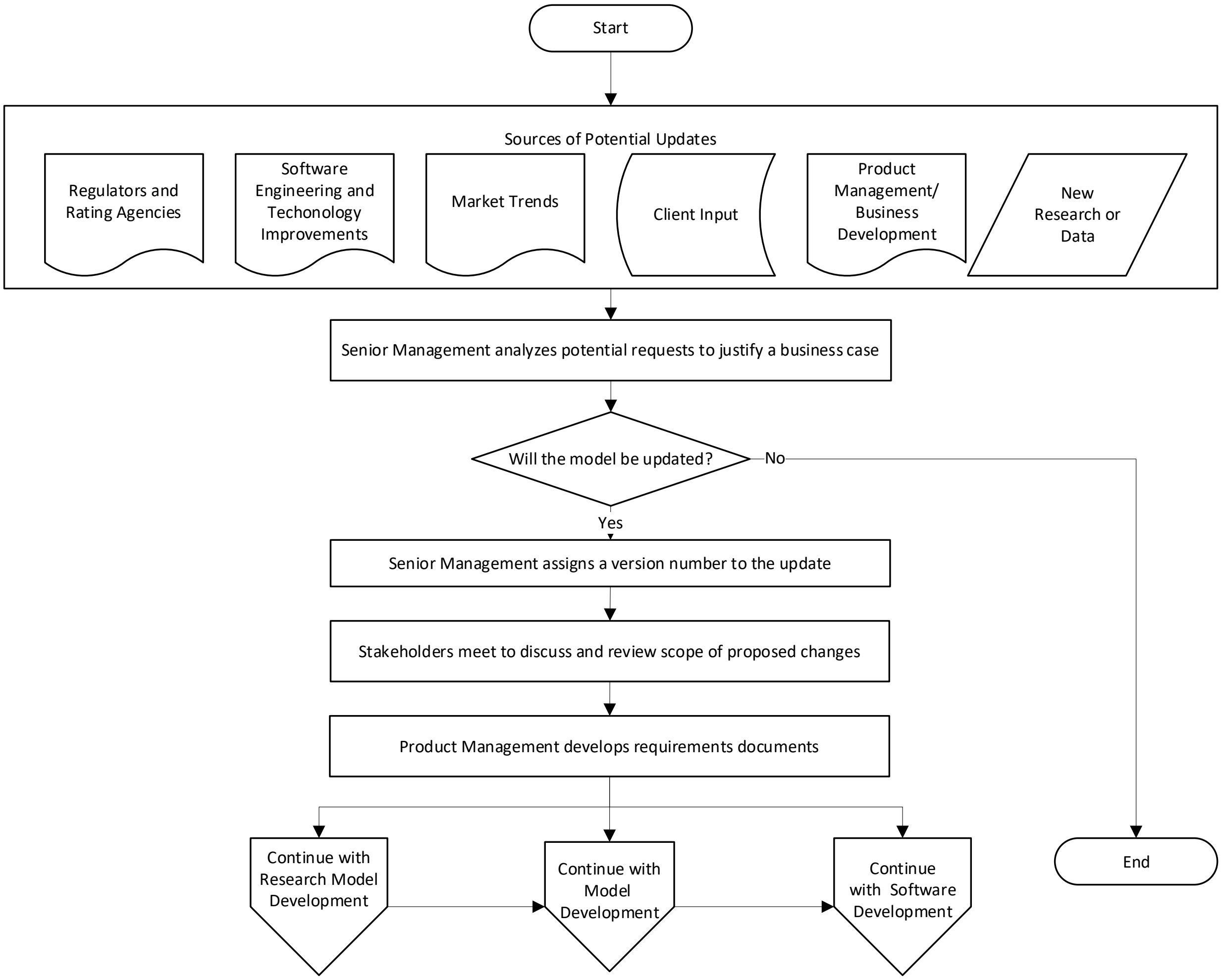
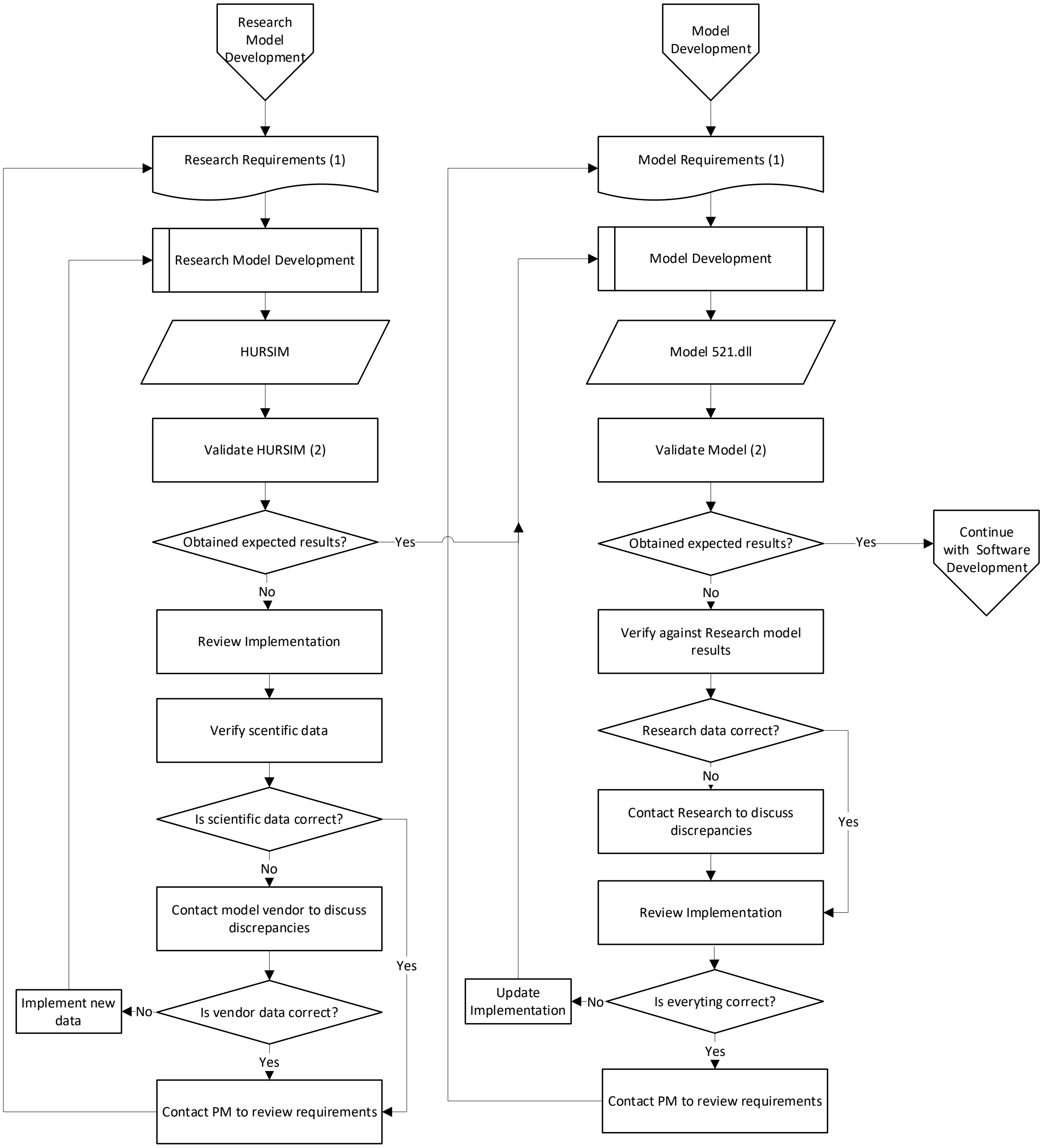


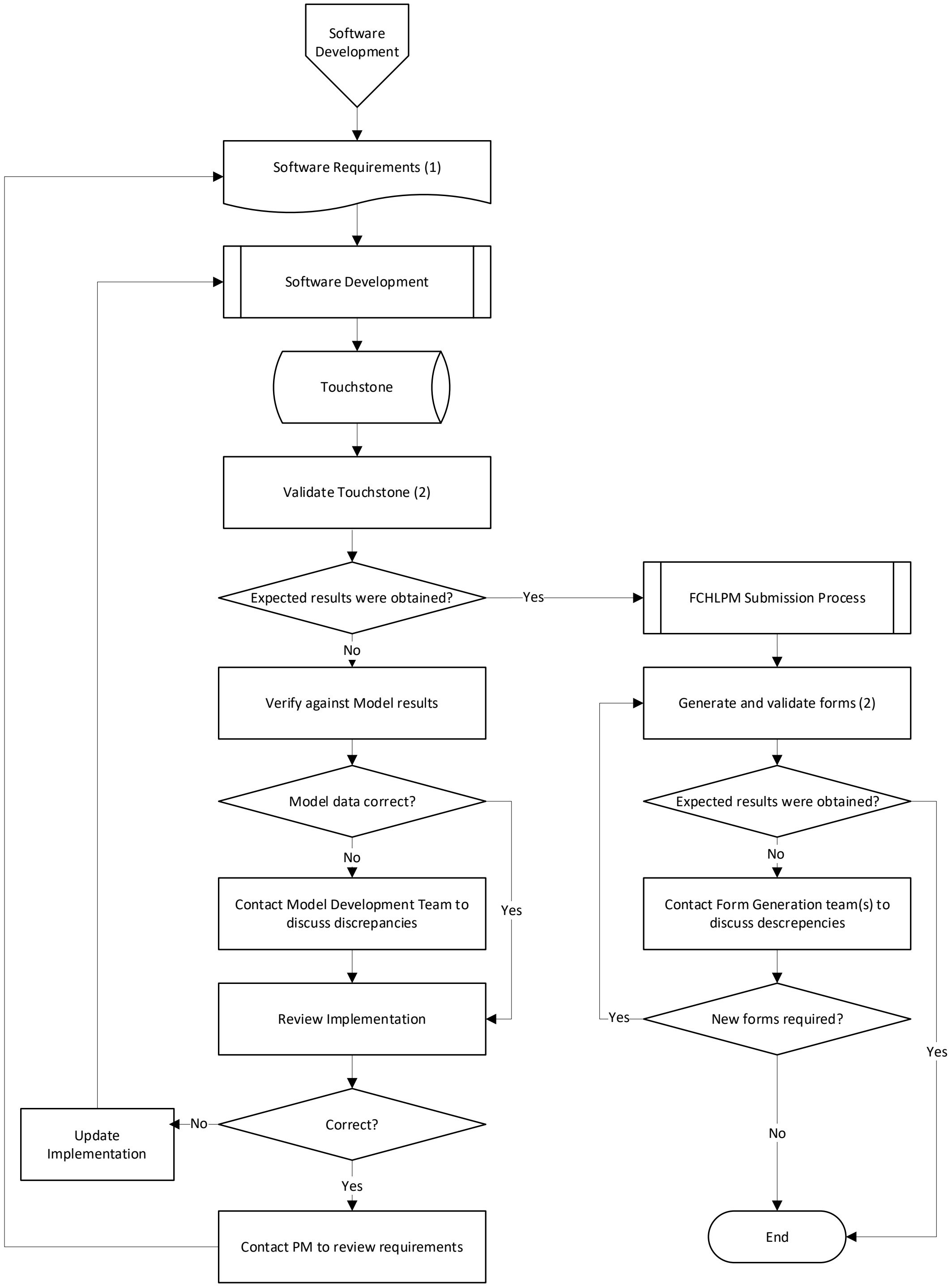
Figure 39. Development and Implementation High Level Overview



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 40. Development and Implementation Overview (continued)



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 41. Development and Implementation Overview (continued)

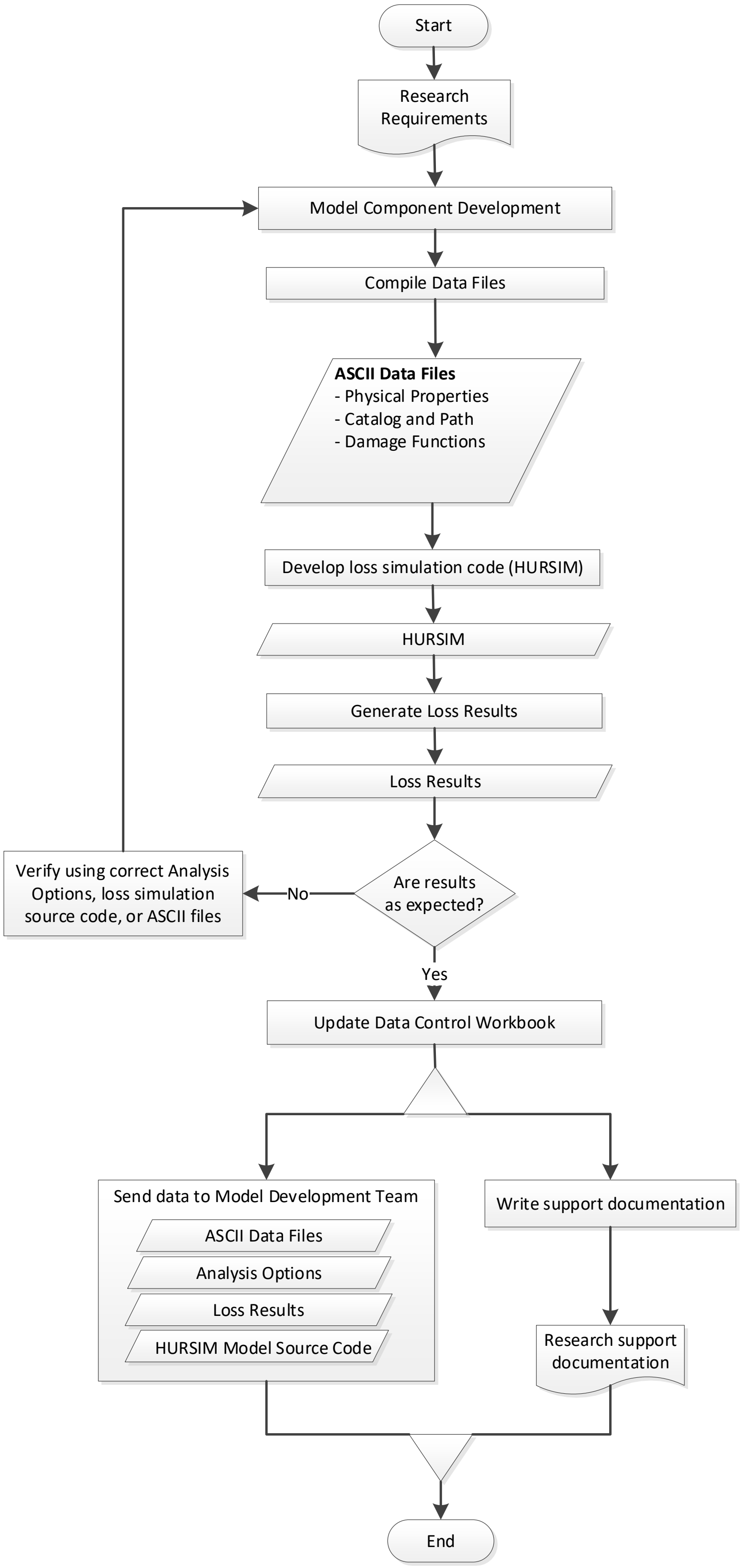


Figure 42. Model Development Process--Research Group

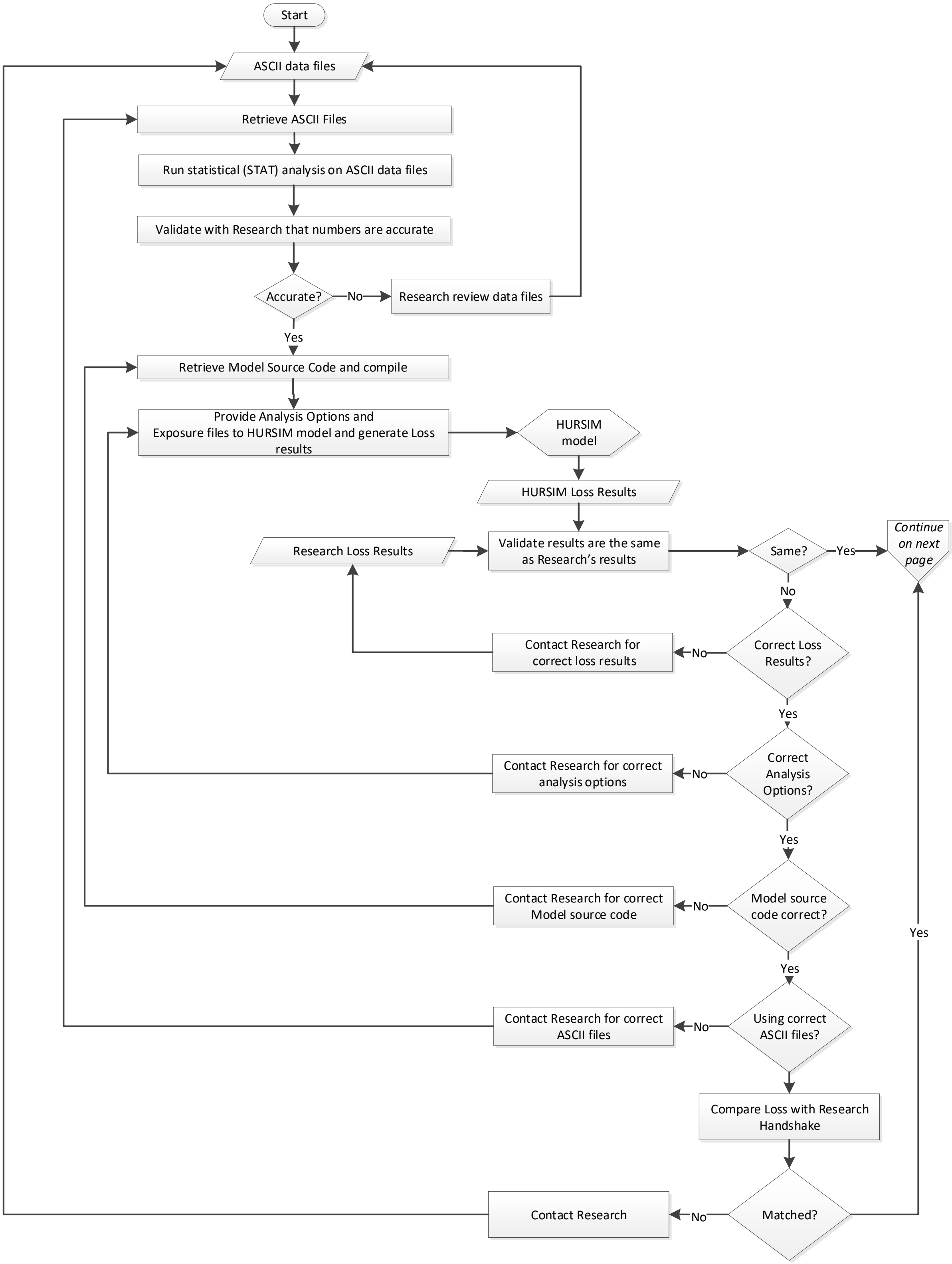


Figure 43. Model 521 Porting and Implementation inTouchstone (Part 1)

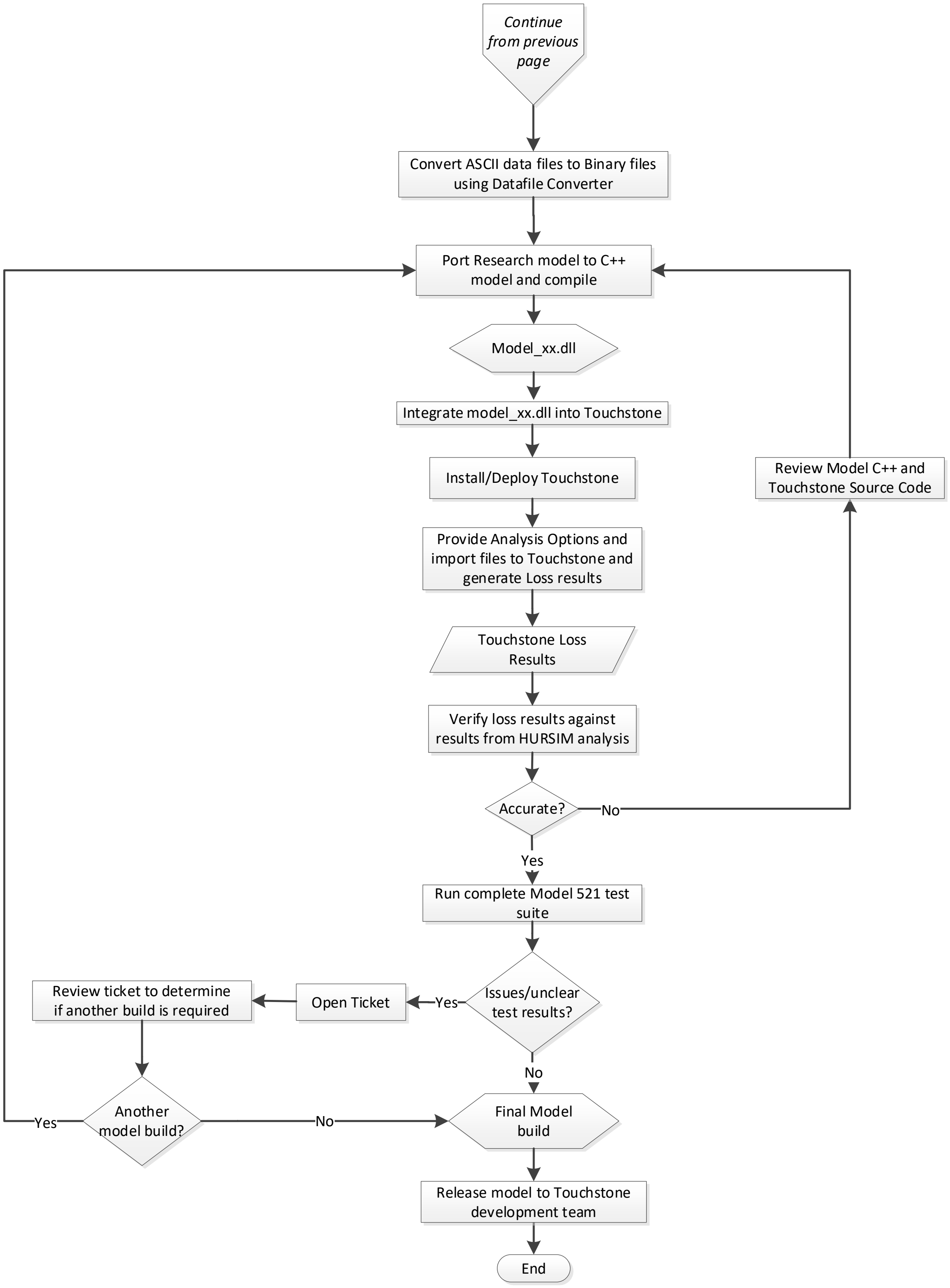


Figure 44. Model 521 Porting and Implementation in Touchstone (Part 2)

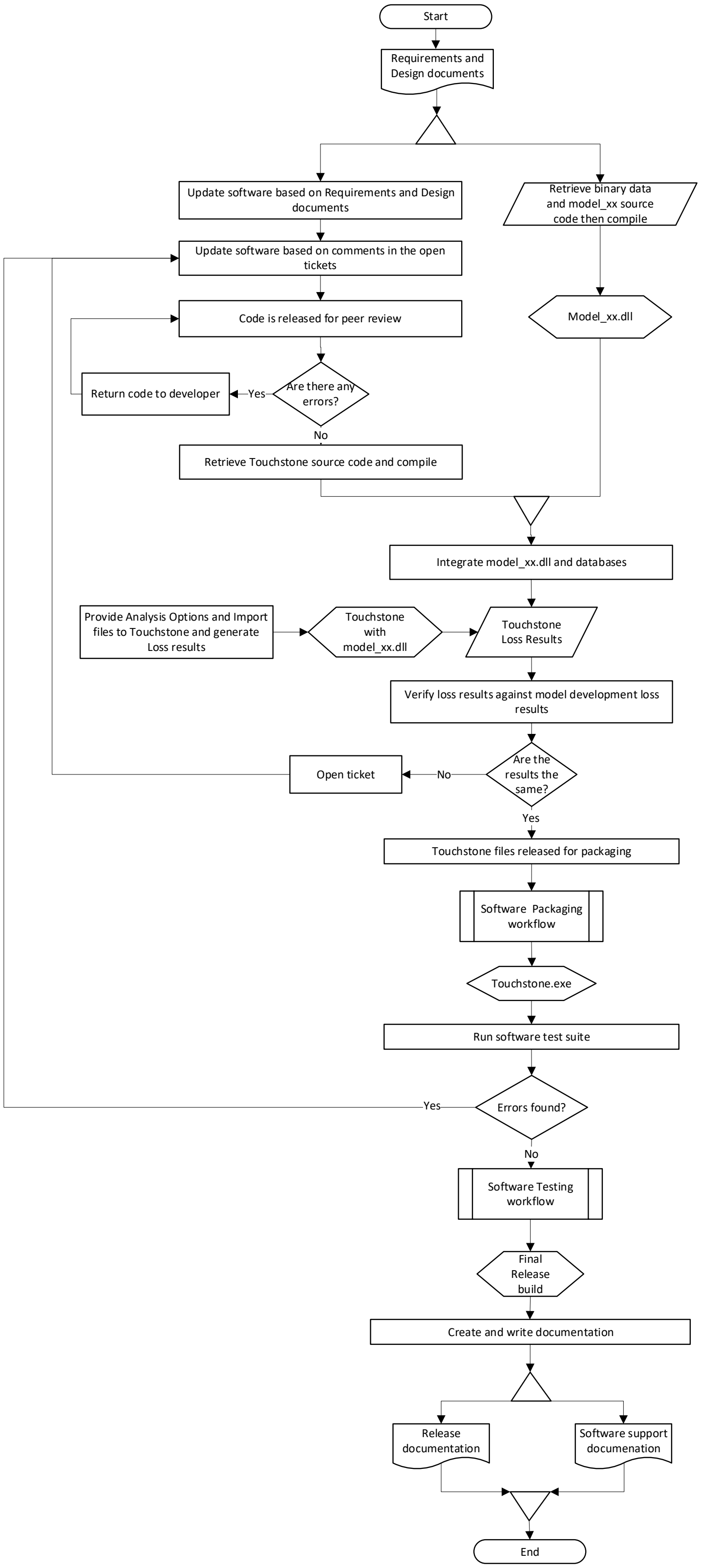


Figure 45. Touchstone Development and Validation

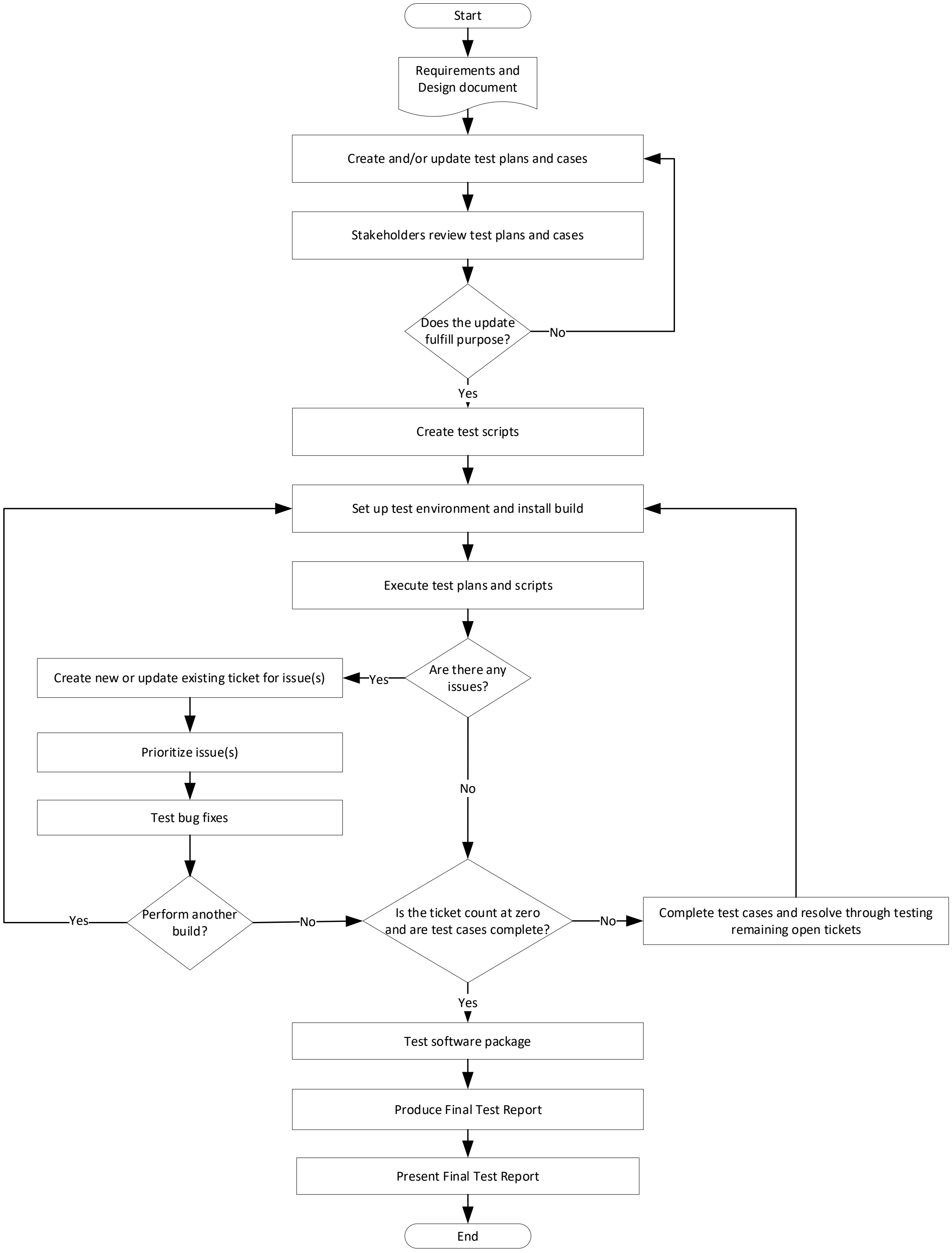


Figure 46. Touchstone Testing Process Overview

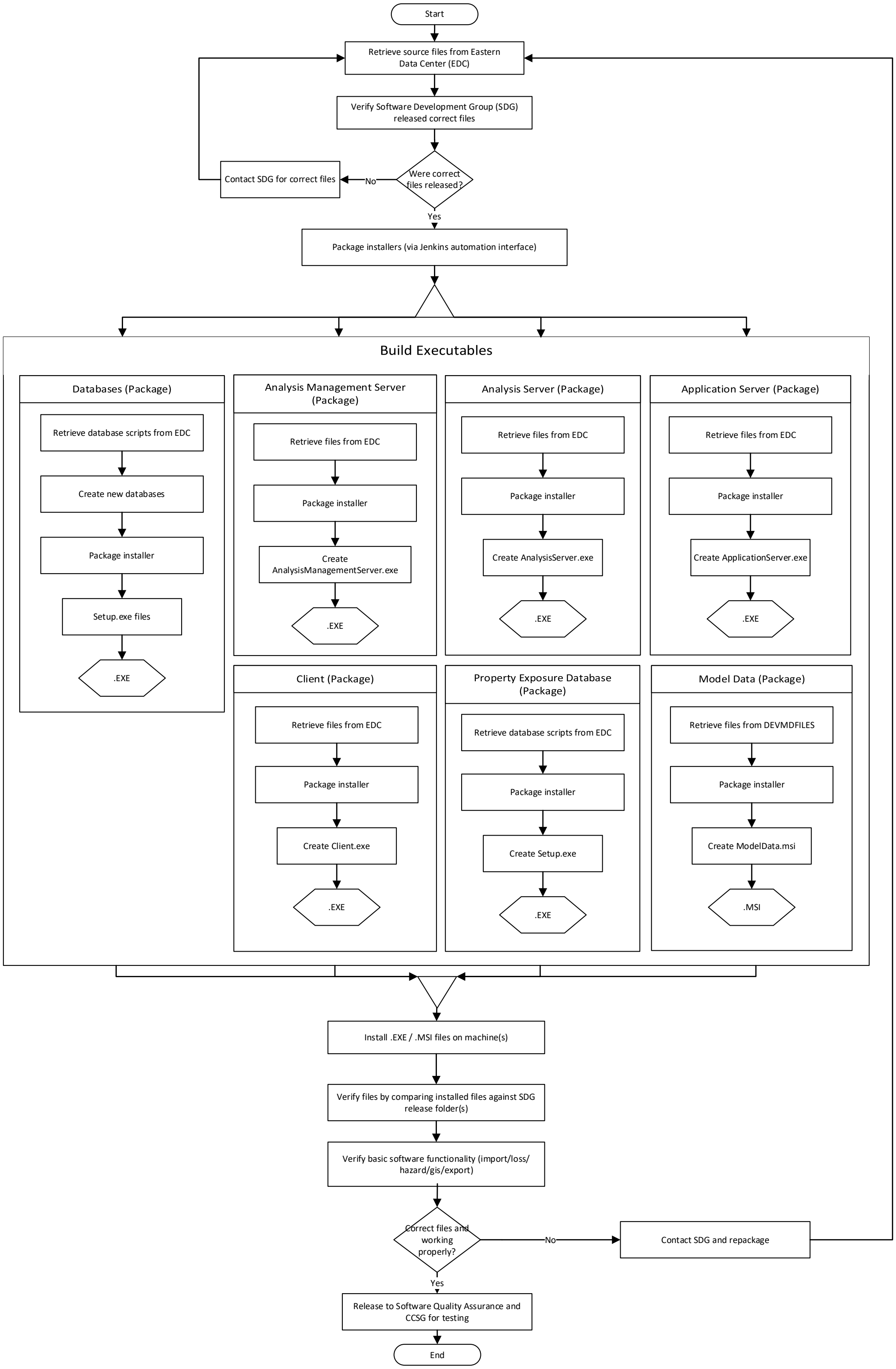


Figure 47. Touchstone Packaging and Release

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

The AIR Business Process Mapping Standards document contains AIR’s internally-developed standard for flowcharts. AIR flowcharts are created in accordance with these standards. It includes AIR Best Practices and describes the symbols that AIR 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

Relevant Forms

- G-6, Computer/Information Standards Expert Certification

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

AIR maintains a complete set of software engineering practices and coding guidelines that are followed by the software developers, including FORTRAN, C++/COM, C#/.Net, Java and SQL. These guidelines are available for inspection by the independent peer auditor and by the Professional Team.

B. Network organization documentation shall be maintained.

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 the following figure:

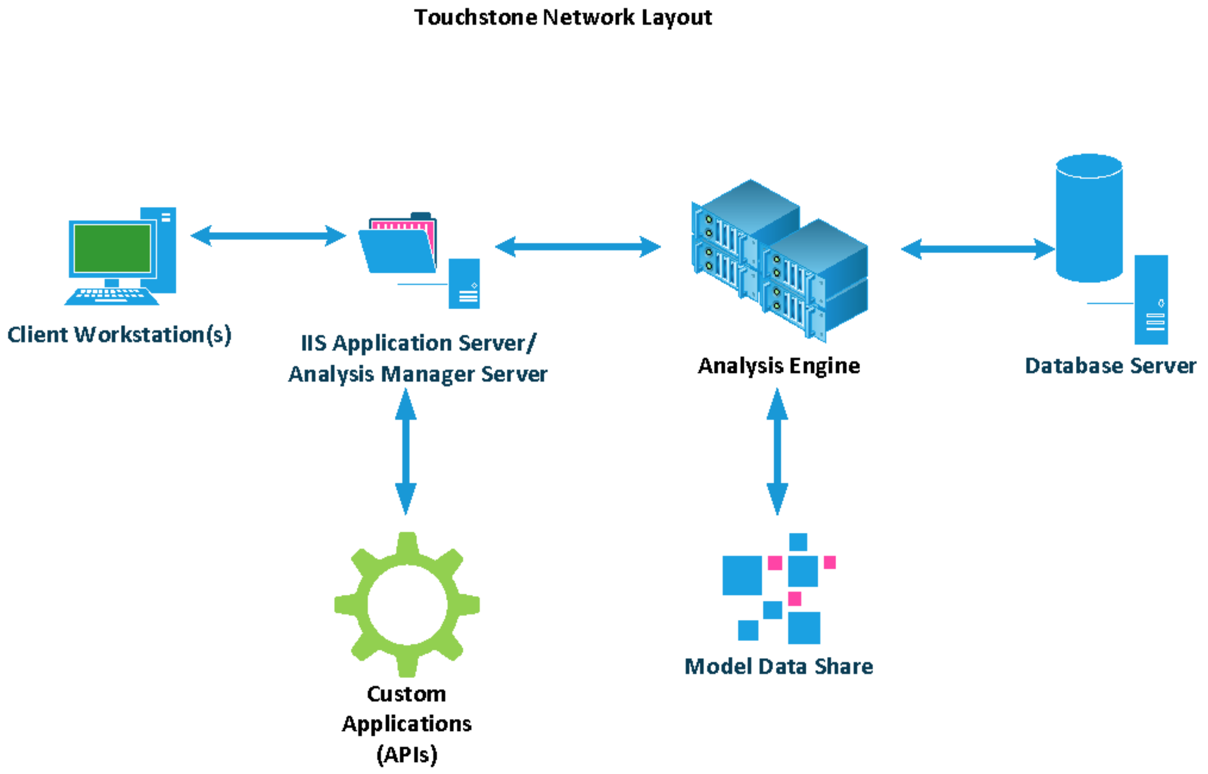


Figure 48. Touchstone Network Layout

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 at www.air-worldwide.com after login.

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

AIR 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.

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

AIR 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.*

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.*

AIR 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.

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.*

AIR documentation can be used by new software engineers to gain an understanding of the software being reviewed. AIR 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.

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

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

The *Model 521 Equations/Formulas, Variable Mapping, and Crosschecking* document discusses the implementation of equations.

Changes to the hurricane model for each revision are documented in the release notes for each version at the time of release. The Enhancements and Florida Commission Documentation Mapping spreadsheet provides a list of all changes since the last release approved by the Florida Commission and the rationale for each change.

AIR's TFS server version control system provides for comments to be added by the developer each time a change is made.

AIR's Clear Quest software provides the means to track all issues and their resolutions.

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

The *Model 521 Equations/Formulas, Variable Mapping, and Crosschecking* document discusses the implementation of the equation used to calculate wind speed, including the FORTRAN subroutines, mapping to C++ functions, and crosscheck verification.

Model and software development custodians shall be available to illustrate the implementation of the equation and crosscheck verification.

Disclosures

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. AIR'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 2016
- Windows Server 2019

Microsoft SQL Servers

- SQL Server 2016 SP2(CU11)
- SQL Server 2017 (CU18)

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 2016 with Update 3

Processor

- AIR builds, tests, and deploys all AIR software on machines with Intel-based processors. AIR does not recommend or support non-Intel processors.

Minimum Resource Requirements

Table 19 defines the minimum core, RAM, and disk space requirements for the Touchstone components.

Table 19. 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	250 GB[1]	• 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	50 GB	• 1/None
Model Data[2]	4	8 GB	1.5 TB[3]	• Currently catalogs are installed on the compute node

1 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 250 GB requirement.

2 Starting with Version 2.0, AIR now supports a centralized model data share.

3 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 20 defines the physical memory limits as defined by the OS version.

Table 20. Physical Memory Limits

Operating System	Max Supported Memory
Windows 10	4 TB
Windows Server 2016	24 TB
Windows Server 2019	24 TB

Certified Platforms and Configuration

Table 21 identifies the platforms certified by AIR.

Table 21. Certified Platforms

	Operating System			SQL Server		HPC Pack
Touchstone 2020	Win 10	Win Server 2016	Win Server 2019	SQL Server 2016 SP2 (CU11)	SQL Server 2017 (CU18)	HPC 2016 Update 3
Databases		✓	✓	✓	✓	
Analysis Management		✓	✓			✓
Analysis Server		✓	✓			✓
Application Server		✓	✓			✓
Client Machine	✓	✓	✓			

Table 22 defines the certified OS or software that is required for the components.

Table 22. Certified Configuration

Touchstone Component	Scalability/Redundancy
Database Servers	• Windows Server 2016 and Windows Server 2019, Standard/Enterprise Editions • SQL Server 2016 SP2 or SQL Server 2017, Standard/Enterprise Editions
Analysis Management Servers (HN)	• Windows Server 2016 and Windows Server 2019, Standard/Enterprise Editions • HPC Pack 2016 Update 3 (Head Node Components)
Analysis Server (CN)	• Windows Server 2016 and Windows Server 2019, Standard/Enterprise Editions • HPC Pack 2016 Update 3 (Compute Node Components)

Touchstone Component	Scalability/Redundancy
Application Server (IIS)	• Windows Server 2016 and Windows Server 2019, Standard/Enterprise Editions • HPC Pack 2016 Update 3 (Client Utilities)
Client Machine (UI)	• Windows Server 2016 and Windows Server 2019, Standard/Enterprise Editions • Windows 10

Upgrade Paths

For clients with Touchstone 2020 who want the least amount of environment reconfiguration, use the upgrade guidelines summarized in Table 23. Note that this path will not ensure complete future Touchstone compatibility.

Table 23. Least Impact Upgrade Path

Touchstone Component	Operating System Version	HPC Pack Version	SQL Server Version
Databases	Windows Server 2016 or Windows Server 2019	N/A	SQL Server 2016 or SQL Server 2017
Analysis Management	Windows Server 2016 or Windows Server 2019	HPC Pack 2016 Update 3	N/A
Analysis Server	Windows Server 2016 or Windows Server 2019	HPC Pack 2016 Update 3 Compute Node	N/A
Application Server	Windows Server 2016 or Windows Server 2019	HPC Pack 2016 Update 3 Client Utilities	N/A
Client	Windows 10/WS 2016/WS 2019	N/A	N/A

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 24 below.

Table 24. Maximum Impact Upgrade Path

Touchstone Component	Operating System Version	HPC Pack Version	SQL Server Version
Databases	Windows Server 2016 or Windows Server 2019	N/A	SQL Server 2016 SP2 or SQL Server 2017
Analysis Management	Windows Server 2016 or Windows Server 2019	HPC Pack 2016 Update 3 Head Node	N/A
Analysis Server	Windows Server 2016 or Windows Server 2019	HPC Pack 2016 Update 3 Compute Node	N/A
Application Server	Windows Server 2016 or Windows Server 2019	HPC Pack 2016 Update 3 Utilities	N/A
Client	Windows 10/WS 2016/WS2019	N/A	N/A

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 AIR logins, and perform an in-place upgrade, to accommodate the transition to SQL 2016 or SQL 2017 and Windows 2016. This will not apply to new installations of Touchstone 2020.

HPC Pack Breakdown

Table 25 below is a simple guide to which HPC component is required and what operating system is supported.

Table 25. HPC Pack Breakdown

Touchstone Component	Operating System Version	HPC Pack Component
Analysis Management Server	Windows Server 2016 or Windows Server 2019	HPC Pack 2016 Update 3
Analysis Server	Windows Server 2016 or Windows Server 2019	HPC Pack 2016 Update 3
Application Server	Windows Server 2016 or Windows Server 2019	HPC Pack 2016 Update 3
Analysis Management and Application Server	Windows Server 2016 or Windows Server 2019	HPC Pack 2016 Update 3

⚠ Important: HPC 2016 can only be installed to SQL Server 2016/2017 instances, even express; the type of instance that can be installed through the HPC installer.

Model Data Disk Space Requirements

Touchstone 2020 offers model data in two packages:

- 10K/50k/500k/Hazard Package
- 100K Package

Disk space requirements for these two packages are summarized in Table 26.

Table 26. Model Data Disk Space Requirements

Region of Data/Peril	Disk Space Required (GB)	
	10K/50K/500K	100K
Asia Pacific		
• Earthquake (includes India)	141.69	79
• Bushfire	2.02	20.10
• Typhoon (Tropical Cyclone)	66.3	-
• Severe Thunderstorm	14.7	35.5
• Inland Flood	1.4	
• Terrorism	0.12	

Region of Data/Peril	**Disk Space Required (GB)**	
	10K/50K/500K	100K
Caribbean		
• Tropical Cyclone (Hurricane)	212.95	
• Earthquake	13.2	
Central America		
• Tropical Cyclone (Hurricane)	212.95	
• Earthquake	0.19	
Europe		
• Earthquake	0.43	
• Extratropical Cyclone	39.0	
• Inland Flood	9.8	
• Severe Thunderstorm	2.70	
• Terrorism	0.12	
North America		
• Earthquake	271.78	1.43
• Inland Flood	681.50	
• Hurricane (Tropical Cyclone)	221.79	20.00
• Severe Thunderstorm	162.78	200.9
• Terrorism	.13	
• Wildfire	91.60	
• Winter Storm (Extratropical Cyclone)	5.50	
South America		
• Earthquake	15.30	
• Terrorism	0.12	

Development Tools and Dependencies

Table 27 defines the Touchstone development tools and dependencies.

Table 27. Touchstone Development Tools and Dependencies

Category	Item	Description	Version
Third Party	Industry Tool	7-Zip 19.00 (x64)	19
Third Party	Industry Tool	Adobe Acrobat Reader DC	2020.012.20043
Third Party	Industry Tool	AQTime	8.41.1556.7

Category	Item	Description	Version
Third Party	Industry Tool	ArcGIS 10.6 for Desktop	10.6.8321
Third Party	Industry Tool	Beyond Compare	4.3.4
Third Party	Industry Tool	C++ | Visual Fortran Compiler	16.0.1.146
Third Party	Industry Tool	C++ Integration(s) in Microsoft Visual Studio* 2015	16.0.1.146
Third Party	Industry Tool	Cisco AnyConnect Secure Mobility Client	3.1.02040
Third Party	Industry Tool	Cisco Webex Meetings	40.4.7
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	FireEye Endpoint Agent	32.30.0
Third Party	Industry Tool	Folder Size 2.8.0.0	2.8.0.0
Third Party	Industry Tool	Fortran 95 interfaces for BLAS and LAPACK for IA-32	11.3.1.146
Third Party	Industry Tool	Fortran 95 interfaces for BLAS and LAPACK for Intel® 64	11.3.1.146
Third Party	Industry Tool	Google Chrome	83.0.4103.116
Third Party	Industry Tool	Google Earth Pro	7.3.1.4507
Third Party	Industry Tool	GoTo Opener	1.0.530
Third Party	Industry Tool	HDF5	1.8.11
Third Party	Industry Tool	HPC	2016 (5.3.6435.0)
Third Party	Industry Tool	IIS 10.0 Express	10.0.1743
Third Party	Industry Tool	IIS Express Application Compatibility Database for x64	
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 Visual Fortran	90
Third Party	Industry Tool	Intel(R) Parallel Studio XE 2019 Update 4	2019.0.4.066
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 Core SDK 2.1.509 (x64)	2.1.509
Third Party	Industry Tool	Microsoft .NET Framework	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 Office 365 ProPlus - en-us	16.0.12527.20988

Category	Item	Description	Version
Third Party	Industry Tool	Microsoft OneDrive	20.143.0716.0003
Third Party	Industry Tool	Microsoft SQL Server	13.0.1601.5
Third Party	Industry Tool	Microsoft SQL Server 2016 Management Objects	13.0.1601.5
Third Party	Industry Tool	Microsoft SQL Server 2016 Management Objects (x64)	13.0.1601.5
Third Party	Industry Tool	Microsoft SQL Server 2016 T-SQL Language Service	13.0.14500.10
Third Party	Industry Tool	Microsoft SQL Server 2016 T-SQL ScriptDom	13.0.1601.5
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 - 18.0 Preview 4	15.0.18040.0
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 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 2010	14.0.7015.1000
Third Party	Industry Tool	Microsoft Visual C++	14.12.25810.0
Third Party	Industry Tool	Microsoft Visual C++ 2010 x64 Redistributable - 10.0.40219	10.0.40219
Third Party	Industry Tool	Microsoft Visual C++ 2012 Redistributable (x64) - 11.0.60610	11.0.60610.1
Third Party	Industry Tool	Microsoft Visual C++ 2012 Redistributable (x86) - 11.0.60610	11.0.60610.1
Third Party	Industry Tool	Microsoft Visual C++ 2013 Redistributable (x64) - 12.0.21005	12.0.21005.1
Third Party	Industry Tool	Microsoft Visual C++ 2013 Redistributable (x64) - 12.0.30501	12.0.30501.0
Third Party	Industry Tool	Microsoft Visual C++ 2013 Redistributable (x86) - 12.0.30501	12.0.30501.0
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	15.8.28010.2016
Third Party	Industry Tool	Microsoft Visual Studio Installer	1.18.1104.625
Third Party	Industry Tool	Microsoft Visual Studio Professional 2015	14.0.23107.178
Third Party	Industry Tool	Microsoft Visual Studio Tools for Applications 2017	15.0.27520
Third Party	Industry Tool	Microsoft XML Parser and SDK	4.00.9004.0
Third Party	Industry Tool	MSBuild	12.0.21005.1
Third Party	Industry Tool	MSXML	4.30.2100.0
Third Party	Industry Tool	Notepad++	7.8.6.0
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

Category	Item	Description	Version
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	Textpad	8.2.0
Third Party	Industry Tool	Total Commander	8.01
Third Party	Industry Tool	Visual Studio Professional 2017	15.9.28307.858
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
AIR-developed Tool	AIR Tool	Datafile Converter	15
Touchstone component	COM_ Component	CATools Components	4.0.0.0
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: AIR Terrorism Loss Estimation Model	3.0.1
Touchstone component	COM_ Component	Model_02: AIR U.S. Workers Compensation	2.1.0
Touchstone component	COM_ Component	Model_03: AIR Japan Personal Accident	1.0.1
Touchstone component	COM_ Component	Model_05: AIR Wildfire Model for California	3.1.0
Touchstone component	COM_ Component	Model_06: Australia Bushfire	3.0.0
Touchstone component	COM_ Component	Model_08: AIR U.S. Flood	3.0.0
Touchstone component	COM_ Component	Model_11: AIR Earthquake Model for the U.S.	10.3.0

Category	Item	Description	Version
Touchstone component	COM_ Component	Model_12: AIR Earthquake Model for the U.S. and Canada	4.1.0
Touchstone component	COM_ Component	Model_13: AIR Earthquake Model for Hawaii	1.7.2
Touchstone component	COM_ Component	Model_14: AIR Earthquake Model for Alaska	1.8.1
Touchstone component	COM_ Component	Model_15: AIR Earthquake Model for the Caribbean	3.0.0
Touchstone component	COM_ Component	Model_18: AIR Japan Inland Flood Model	1.0.2
Touchstone component	COM_ Component	Model_21: AIR Hurricane Model for the U.S.	18.0.0
Touchstone component	COM_ Component	Model_22: AIR Severe Thunderstorm Model for the U.S.	7.0.5
Touchstone component	COM_ Component	Model_23: AIR Hurricane Model for Hawaii	3.10.0
Touchstone component	COM_ Component	Model_24: AIR U.S. Hurricane Model for Offshore Assets	1.12.0
Touchstone component	COM_ Component	Model_25: AIR Tropical Cyclone Model for the Caribbean	10.0.0
Touchstone component	COM_ Component	Model_26: AIR Severe Thunderstorm Model for Canada	3.1.2
Touchstone component	COM_ Component	Model_28: AIR Winter Storm Model for the U.S.	1.4.0
Touchstone component	COM_ Component	Model_29: AIR Tropical Cyclone Model for Mexico	1.0.1
Touchstone component	COM_ Component	Model_30: AIR Tropical Cyclone Model for Canada	1.1.0
Touchstone component	COM_ Component	Model_31: AIR Earthquake Model for the Pan-European Region	4.0.0
Touchstone component	COM_ Component	Model_33: AIR Earthquake Model for South East Europe	3.0.0
Touchstone component	COM_ Component	Model_41: AIR Extratropical Cyclone Model for Europe	7.0.0
Touchstone component	COM_ Component	Model_42: AIR Winter Storm Model for Canada	1.1.0
Touchstone component	COM_ Component	Model_43: AIR Severe Thunderstorm Model for Europe	1.0.0
Touchstone component	COM_ Component	Model_44: AIR Severe Thunderstorm Model for Australia	1.1.0
Touchstone component	COM_ Component	Model_51: AIR Earthquake Model for Australia	5.0.0
Touchstone component	COM_ Component	Model_52: AIR Earthquake Model for Japan	6.4.3

Category	Item	Description	Version
Touchstone component	COM_ Component	Model_53: AIR Earthquake Model for New Zealand	4.0.0
Touchstone component	COM_ Component	Model_54: AIR Earthquake Model for Southeast Asia	4.2.0
Touchstone component	COM_ Component	Model_55: AIR Earthquake Model for China	1.3.0
Touchstone component	COM_ Component	Model_58: AIR Earthquake Model for India	1.0.0
Touchstone component	COM_ Component	Model_61: AIR Cyclone Model for Australia	2.2.0
Touchstone component	COM_ Component	Model_62: AIR Typhoon Model for Japan	6.0.2
Touchstone component	COM_ Component	Model_64: AIR Typhoon Model for Southeast Asia	3.0.0
Touchstone component	COM_ Component	Model_65: AIR Typhoon Model for China	13.1.0
Touchstone component	COM_ Component	Model_66: AIR Typhoon Model for South Korea	2.1.0
Touchstone component	COM_ Component	Model_67: AIR Tropical Cyclone Model for Central America	2.2.2
Touchstone component	COM_ Component	Model_68: AIR India Tropical Cyclone	2.2.0
Touchstone component	COM_ Component	Model_70: AIR Earthquake Model for South America	1.1.0
Touchstone component	COM_ Component	Model_72: AIR Earthquake Model for Mexico	2.0.0
Touchstone component	COM_ Component	Model_76: AIR Earthquake Model for Central America	1.0.0
Touchstone component	COM_ Component	Model_87: AIR Multiple-Peril Crop Insurance Model for India	1.0.0
Touchstone component	COM_ Component	Model_90: AIR Inland Flood Model for Central Europe	2.0.0
Touchstone component	COM_ Component	Model_92: AIR Inland Flood Model for Great Britain	1.1.1
Touchstone component	COM_ Component	Model_94: AIR Inland Flood Model for South East Europe	1.0.0
Touchstone component	COM_ Component	Model_521: AIR Hurricane Model for the U.S.	1.0.0

Computer Languages

The computer languages employed at AIR include:

- FORTRAN
- C++
- Microsoft C#

- SQL
- WPF/WCF/XAML

Standard CI-5: Hurricane Model Verification

Relevant Forms

- G-6, Computer/Information Standards Expert Certification

A. General

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

AIR 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.

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.

B. Component Testing

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

Tools used during the testing process include:

- SilkTest: Build and execute automated test cases.
- Beyond Compare: Compare and validate test output and results.
- ClearQuest: Bug tracking and process management.
- Excel: General analytics and reporting
- ArcGIS: Geo-spatial validation
- Team Foundation Server: Test management

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

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) Regression tests shall be performed and documented on incremental builds.

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 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.

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.

C. Data Testing

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

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

AIR runs tests that check for integrity, consistency and correctness of all databases and data files that are accessed by the model components. For instance, AIR 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.

Additionally, for databases, AIR performs data validation on 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 shall available to the independent peer auditor and to the Professional Team.

Disclosures

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 & 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.

AIR 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.

2. Provide an overview of the component testing procedures.

Hurricane model component testing procedures are divided into three broad sections. These include procedures to 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.

3. Provide a description of verification approaches used for externally acquired data, software, and models.

AIR 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 Table 28.

Table 28. 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 2019 are available at https://www.nhc.noaa.gov/pastall.shtml	Downloaded data is compared to original versions. No additional validation is done.
HURDAT2 Chronological List of All Hurricanes which Affected the Continental United States: 1851-2018	Provides a chronological list of all hurricanes which affected the continental U.S. from 1851-2019. Revised in February 2015 to include the 2019 season and reflects official HURDAT reanalysis changes through 1955. Available at https://www.aoml.noaa.gov/hrd/hurdat/All_U.S._Hurricanes.html	Downloaded data is compared to original versions. No additional validation is done.
The revised Atlantic hurricane database (HURDAT2)	Provides storm track data for all hurricanes from 1851 to 2019. Storm parameters are provided at 6-hour intervals for the life of the storm, including direction, speed, wind, pressure, and storm rating. Data are also provided at additional points of interest (such as time of landfall). Available at https://www.aoml.noaa.gov/hrd/hurdat/hurdat2.html	Downloaded data is compared to original versions. No additional validation is done.
HURDAT2 Continental U.S. Hurricanes: 1851 to 1930	Provides historic data for hurricanes that occurred from 1851 to 2019. This data was revised in June 2020 to include updates for the U.S. hurricanes through 2019. Available online at https://www.aoml.noaa.gov/hrd/hurdat/Data_Storm.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 2019. 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.

Source Title	Description	Validation Methods
USGS National Land Cover Database (NLCD)	Provides digital and satellite-derived land use/land cover data dating from 2001. 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. Available online at https://www.mrlc.gov/index.php	USGS LULC data are overlaid over satellite imagery to ensure proper data projection has been applied. Additional checking is applied over bodies of water as identified by GIS boundary files. The U.S.G.S. incorrectly designates some of these areas as having land properties, and in these cases the data are corrected to water.
Environics	Provides the population-weighted ZIP Code centroids that are used as part of the annual U.S. exposure update process. Environics creates a population weighted centroid for each ZIP Code contained within the update files it provides. 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 Environics is, on average, a year out of date.	The calculation of the population weighted centroids is checked by the Exposures group using the Environics 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 miles are plotted on maps and visually inspected. Any changes that can't be justified are referred to Environics 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 AIR 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 AIR 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 AIR Industry Exposure, and with previous releases of the ACS to ensure consistency.

Source Title	Description	Validation Methods
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.	This 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 AIR Industry Exposure for validation.
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 AIR receives receive quarterly updates of the ZIPInfo data. However, only the version that is closes 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. to 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 Consulting. When appropriate, ClearQuest tickets are opened to ensure that the source of the error is corrected and re-tested.

Standard CI-6: Hurricane Model Maintenance and Revision

Relevant Forms

- G-6, Computer/Information Standards Expert Certification

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.

AIR maintains a clearly documented policy for hurricane model review, maintenance, and revision with respect to methodology and data. AIR 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.

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

AIR 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 AIR 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.

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

AIR uses Salesforce CRM and ClearQuest to track issues/bugs, as well as modifications to code, data, and documentation. Revisions and versioning are managed using the build in versioning capability of Microsoft's Team Foundation Server via Microsoft Visual Studio, as well as Visual SourceSafe (VSS).AIR custodians shall be available to demonstrate issue management via Salesforce and ClearQuest.

Salesforce CRM

Client Services uses Salesforce CRM to track defects, bugs, enhancements, and recommendations submitted by clients and customers. Salesforce CRM is an enterprise level customer relationship management (CRM) that allows AIR to manage client reported cases of technical support issues, including web-based reporting, tracking, documentation, management and resolution of all levels of client technical support.

Issues identified by Client Services using Salesforce CRM are escalated to ClearQuest tickets for further development when the case require extensive requirements gathering, analysis and/or technical, code or model changes.

ClearQuest Tickets

AIR uses ClearQuest to log and manage product enhancements, change requests, and issues management. Any issues/bugs/unexpected results that are identified via the testing process are also tracked using ClearQuest.

Issue/Bug Submission Process

Clients submit bugs or suspect model data errors using the Salesforce CRM. The Salesforce case is assigned to the appropriate group (i.e. Client Consulting, Research, Software Development), which reviews the circumstances and determines if a solution exists that does not require modifications to the application. If so, these solutions are documented in the Salesforce CRM system and provided to the client. When changes to Touchstone or the model are required to fix the issue, AIR follows the standard software development process.

Internal AIR users submit change requests electronically via ClearQuest. There are no restrictions to limit individuals who may submit a request. The workflows in Figure 49 and Figure 50 illustrate the change management processes for the model and Touchstone software.

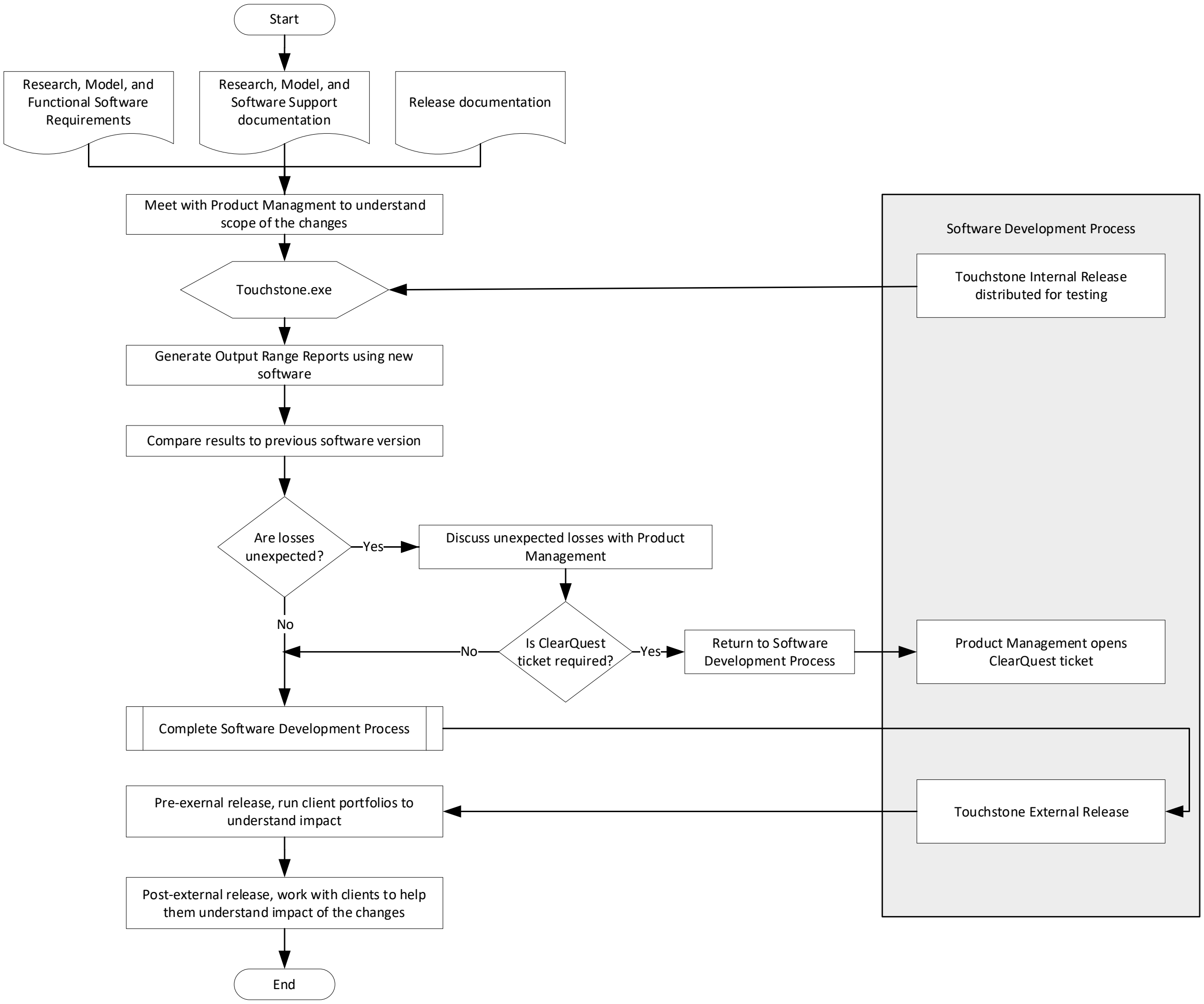


Figure 49. Version Change Management Process

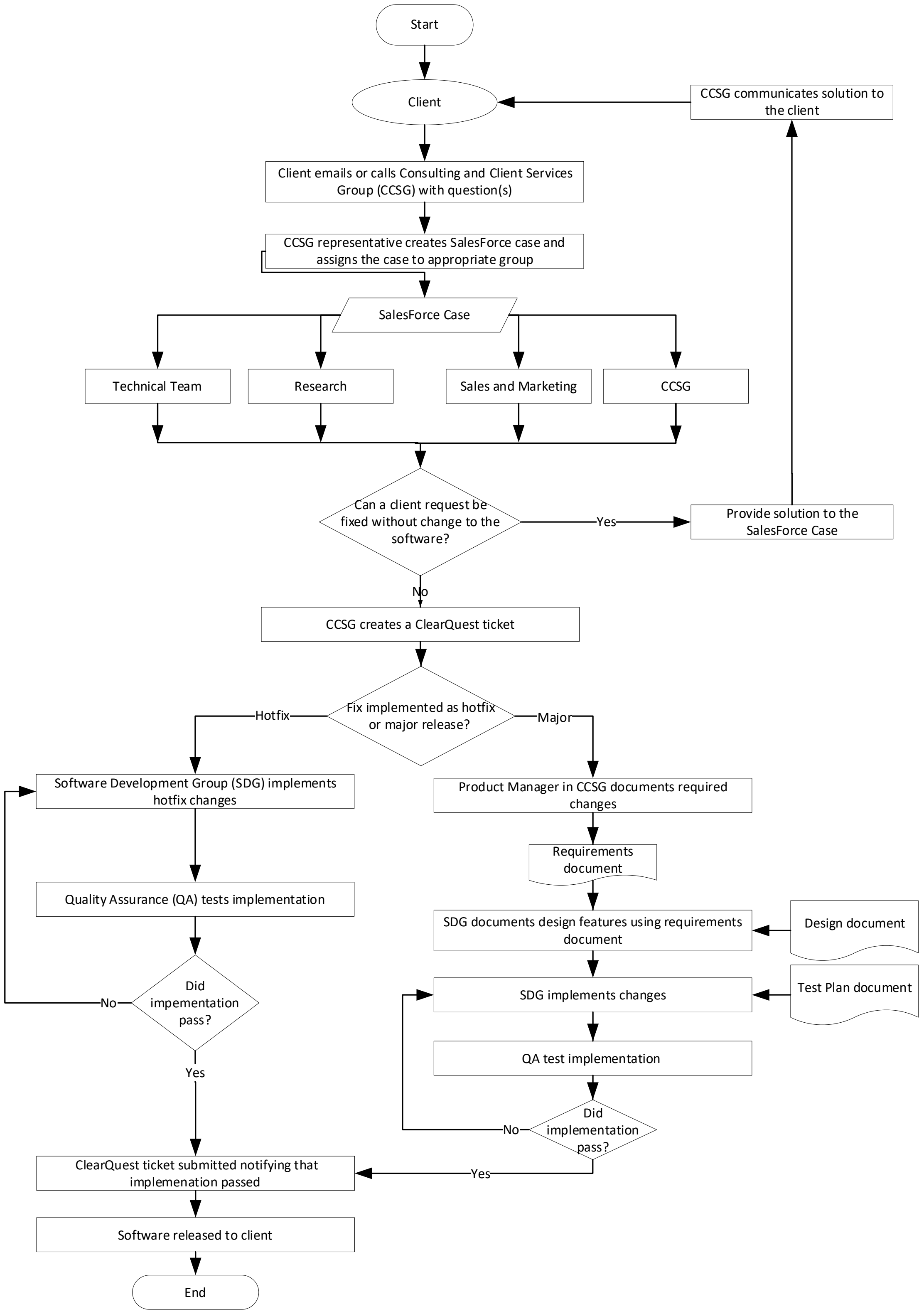


Figure 50. Software Change Management Process

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

The document *Enhancements and Florida Commission Documentation Mapping* identifies the updates specific to the AIR Hurricane Model for the U.S. version 1.0.0 and the Touchstone 2020 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

1. Identify procedures used to review and maintain code, data, and documentation.

AIR 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.

AIR uses Team Foundation Server (TFS) 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 AIR 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 Microsoft's Team Foundation Server (TFS) via Microsoft Visual Studio.

AIR uses Microsoft Office SharePoint Server (internally referred to as AIRPort) to manage project, archive and monitor requirements, store and share client-based or internal documentation or PDF files. Like TFS and VSS, AIRPort tracks installation date, date of most recent changes and version history.

2. Describe the rules underlying the hurricane model and code revision identification systems

The AIR Hurricane Model for the United States is implemented in our software platform, Touchstone. AIR generally produces one major release of Touchstone annually (e.g. Touchstone 2020, Touchstone 2021).

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 AIR Hurricane Model for the U.S. 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 AIR software. For example, it is used when a client requests an update to be compatible with their technical environment.

Standard CI-7: Hurricane Model Security

Relevant Forms

- G-6, Computer/Information Standards Expert Certification

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.

AIR 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 AIR 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 Mbps Ethernet switches for fast throughput. AIR also has Linux servers, which are primarily used for research and development of AIR 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 AIR 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 AIR employees.

As a directive from Verisk, every employee at AIR 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. AIR policy is to maintain the minimum number of open ports necessary.
- Network logon (internal)—Access to the network via workstations at AIR's main office is restricted to AIR-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 AIR network access approval. IS 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 AIR's main office is subject to the internal network logon restrictions mentioned above, as well as access via the VPN gateway. VPN accounts are granted with management approval only.
- Branch offices and remote users—Access to the network from AIR's 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 AIR'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 data servers are located in a secure server room located in New Jersey.

All model and software development is done within AIR'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 AIR's Internal Source Code present in TFS, GitHub Enterprise, and VSS is limited to the AD accounts /AD Groups, approved and created by IT Database Team. We have Certain AD Groups that are predefined as 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 hierarchal to the department leads and/or through a help desk request.

Access to AIRPort—All AIR employees have access to AIRPort. 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 AIR Worldwide FTP Servers are contained within the DMZ zone and are accessed in a secure manner. In computer networks, a DMZ (demilitarized zone) 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

AIR 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 AIR 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/SSH to connect to Linux resources. Since the home PC is not part of the AIR Worldwide 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 AIR Windows user name and password.

Using the VPN gateway to access the workstation at AIR Worldwide 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. AIR 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

AIR Worldwide 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 Boston servers and our Intranet via the VPN gateway.

File Back-up

To provide a safety net to AIR's network, AIR 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 AIR Atlantic Tropical Cyclone Model.

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 AIR 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. IS-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.

AIR 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 AIR. The goal is to determine if an authorized entity from AIR 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 AIR'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.

Recovery

If the Business Continuity Plan is activated, it means that AIR's 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 AIR's headquarters was damaged, continuity plans were activated, and employees and operations were relocated. During the restoration phase, the ERT stays at the AIR Headquarters to assess the extent, impact, and damage of any incident. They communicate with the RMT who will decide whether/when AIR 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

AIR 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 AIR's floor is restricted to current AIR employees and guests. All AIR Employees are issued an electronic security badge on the first day of their employment. All AIR employees (including employees visiting from other offices) should have their AIR 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 AIR 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 AIR receptionist and must be escorted by an AIR 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 AIR staff have been trained (Emergency Evacuation Team) to inform and guide employees in the event of an evacuation.

Disclosure

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.***

AIR 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.

AIR's security policies, which are outlined above, are discussed in the Verisk Information Security Policy Framework document. An AIR custodian shall be available to further discuss the AIR 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.

Appendix 1: General Standards

Form G-1: General Standards Expert Certification

I hereby certify that I have reviewed the current submission of The AIR Hurricane Model for the United States, Version 1.0.0 as implemented in Touchstone 2020, for compliance with the 2019 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology, and hereby certify that:

1. The hurricane model meets the General Standards (G-1 – G-5);
2. The disclosures and forms related to the General 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.

Brandie Andrews
Name

M.P.A. Public Administration
Professional Credentials (Area of Expertise)

Signature (original submission)

October 27, 2020
Date

Signature (response to deficiencies, if any)

February 3, 2021
Date

Signature (revisions to submission, if any)

Date

Signature (final submission)

Date

An updated signature and form are required following any modification of the hurricane model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Form G-1: General Standards Expert Certification

I hereby certify that I have reviewed the current submission of The AIR Hurricane Model for the United States, Version 1.0.0 as implemented in Touchstone 2020, for compliance with the 2019 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology, and hereby certify that:

1. The hurricane model meets the General Standards (G-1 – G-5);
2. The disclosures and forms related to the General 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.

Brendan Flaherty
Name

B.A., Mathematics
Professional Credentials (Area of Expertise)

Signature (original submission)
Date

Signature (response to deficiencies, if any)
Date

Signature (revisions to submission, if any)
Date

Signature (final submission)

May 19, 2021
Date

An updated signature and form are required following any modification of the hurricane model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)
Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Form G-2: Meteorological Standards Expert Certification

I hereby certify that I have reviewed the current submission of The AIR Hurricane Model for the United States, Version 1.0.0 as implemented in Touchstone 2020, for compliance with the 2019 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology, and hereby certify that:

1. The hurricane model meets the Meteorological Standards (M-1 – M-6);
2. The disclosures and forms related to the Meteorological 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 27, 2020
Signature (original submission)	Date
	February 3, 2021
Signature (response to deficiencies, if any)	Date
Signature (revisions to submission, if any)	Date
	May 19, 2021
Signature (final submission)	Date

An updated signature and form are required following any modification of the hurricane model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)	Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Form G-3: Statistical Standards Expert Certification

I hereby certify that I have reviewed the current submission of The AIR Hurricane Model for the United States, Version 1.0.0 as implemented in Touchstone 2020, for compliance with the 2019 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology, and hereby certify that:

1. The hurricane model meets the Statistical Standards (S-1 – S-6);
2. The disclosures and forms related to the Statistical 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.

Suilou Huang
Name

M.S. Statistics, Ph.D. Oceanography
Professional Credentials (Area of Expertise)

Signature (original submission)

October 27, 2020
Date

Signature (response to deficiencies, if any)

February 3, 2021
Date

Signature (revisions to submission, if any)

Date

Signature (final submission)

May 19, 2021
Date

An updated signature and form are required following any modification of the hurricane model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Form G-4: Vulnerability Standards Expert Certification

I hereby certify that I have reviewed the current submission of The AIR Hurricane Model for the United States, Version 1.0.0 as implemented in Touchstone 2020, for compliance with the 2019 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology, and hereby certify that:

1. The hurricane model meets the Vulnerability Standards (V-1 – V-4);
2. The disclosures and forms related to the Vulnerability 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)
Carol Friedland	**October 19, 2020**
Signature (original submission)	Date
Carol Friedland	**February 3, 2021**
Signature (response to deficiencies, if any)	Date
Signature (revisions to submission, if any)	Date
Carol Friedland	**May 19, 2021**
Signature (final submission)	Date

An updated signature and form are required following any modification of the hurricane model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)	Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Form G-5: Actuarial Standards Certification

I hereby certify that I have reviewed the current submission of The AIR Hurricane Model for the United States, Version 1.0.0 as implemented in Touchstone 2020, for compliance with the 2019 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology, and hereby certify that:

1. The hurricane model meets the Actuarial Standards (A-1 – A-6);
2. The disclosures and forms related to the Actuarial Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the Actuarial Standards 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.

Stacey Gotham
Name

FCAS, MAAA
Professional Credentials (Area of Expertise)

Stacey Gotham
Signature (original submission)

October 27, 2020
Date

Signature (response to deficiencies, if any)

Date

Signature (revisions to submission, if any)

Date

Stacey Gotham
Signature (final submission)

May 19, 2021
Date

An updated signature and form are required following any modification of the hurricane model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Form G-6: Computer / Information Standards Expert Certification

I hereby certify that I have reviewed the current submission of The AIR Hurricane Model for the United States, Version 1.0.0 as implemented in Touchstone 2020, for compliance with the 2019 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology, and hereby certify that:

1. The hurricane model meets the Computer/Information Standards (CI-1 – CI-7);
2. The disclosures and forms related to the Computer/Information 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.

Narges Pourghasemi	**M.S. Computer Science**
Name	Professional Credentials (Area of Expertise)
	October 9, 2020
Signature (original submission)	Date
Signature (response to deficiencies, if any)	Date
Signature (revisions to submission, if any)	Date
	May 19, 2021
Signature (final submission)	Date

An updated signature and form are required following any modification of the hurricane model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)	Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Form G-7: Editorial Review Expert Certification

I hereby certify that I have reviewed the current submission of The AIR Hurricane Model for the United States, Version 1.0.0 as implemented in Touchstone 2020, for compliance with the 2019 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology, and hereby certify that:

1. The hurricane model submission is in compliance with the Notification Requirements and General 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.

Heidi Carrell
Name

B.A. English, Senior Writer, AIR
Professional Credentials (Area of Expertise)

Heidi H. Carrell
Signature (original submission)

October 27, 2020
Date

Heidi H. Carrell
Signature (response to deficiencies, if any)

February 3, 2021
Date

Signature (revisions to submission, if any)

Date

Heidi H. Carrell
Signature (final submission)

May 19, 2021
Date

An updated signature and form are required following any modification of the hurricane model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Appendix 2: Meteorological Standards

Form M-1: Annual Occurrence Rates

Standard M-1: Base Hurricane Storm Set

Notes on Form M-1
1. 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.

2. Form M-1, Annual Occurrence Rates; Form A-2, Base Hurricane Storm Set Statewide Hurricane Losses; .and Form S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year, are based on the 119-year period 1900-2018 (consistent with Standard M-1, Base Hurricane Storm Set). It is intended that the storm set underlying Forms M-1, Annual Occurrence Rates; A-2, Base Hurricane Storm Set Statewide Hurricane Losses; and S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year, will be the same.

3. As specified in Standard M-1, Base Hurricane Storm Set, the modeling organization may exclude hurricanes that caused zero modeled damage, or include additional complete hurricane seasons, or may modify data for historical storms based on evidence in current scientific and technical literature. This may result in the modeling organization's Base Hurricane Storm Set differing from the storm set listed in Form A-2, Base Hurricane Storm Set Statewide Hurricane Losses. In this case, the modeling organization should modify the storm set listed in Form A-2, Base Hurricane Storm Set Statewide Hurricane Losses, to make it consistent with the modeling organization's Base Hurricane Storm Set. The modeling organization's Base Hurricane Storm Set shall be used to populate the historical counts and rates of Form M-1, Annual Occurrence Rates, as well as the Florida landfall historical frequency in Form S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year.

A. One or more automated programs or scripts shall be used to generate and arrange the data in Form M-1, Annual Occurrence Rates.

The data in Table 29. Modeled Annual Occurrence Rates was generated by a set of scripts coded in the R language which is under source version control.

B. Provide a table of annual occurrence rates for hurricane landfall from the data set 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 3. List the annual occurrence rate per hurricane category. Annual occurrence rates shall be rounded to three decimal places.

The historical frequencies below have been derived from the Base Hurricane Storm Set as defined in Standard M-1, Base Hurricane Storm Set. If the modeling organization Base Hurricane Storm Set differs from that defined in Standard M-1, Base Hurricane Storm Set, (for example, using a different historical period), the historical rates in the table shall be edited to reflect this difference (see below). As defined, a *by-passing hurricane is a hurricane which does not make landfall on Florida, but produces minimum damaging windspeeds or greater on land in Florida. For the by-passing hurricanes included in the table only, the intensity entered is the maximum windspeed at closest approach to Florida, not the windspeed over Florida.*

Table 29. Modeled Annual Occurrence Rates

	Entire State				Region A – NW Florida			
	Historical		Modeled		Historical		Modeled	
Category	Number	Rate	Number	Rate	Number	Rate	Number	Rate
1	28	0.235	11669	0.233	14	0.118	5109	0.102
2	12	0.101	7088	0.142	5	0.042	2658	0.053
3	16	0.134	6421	0.128	6	0.050	2061	0.041
4	7	0.059	3405	0.068	0	0.000	908	0.018
5	3	0.025	513	0.010	1	0.008	103	0.002

	Region B – SW Florida				Region C – SE Florida			
	Historical		Modeled		Historical		Modeled	
Category	Number	Rate	Number	Rate	Number	Rate	Number	Rate
1	4	0.034	3078	0.062	13	0.109	4074	0.081
2	4	0.034	2067	0.041	4	0.034	2438	0.049
3	6	0.050	1982	0.040	4	0.034	2354	0.047
4	3	0.025	1151	0.023	4	0.034	1295	0.026
5	0	0.000	192	0.004	2	0.017	213	0.004

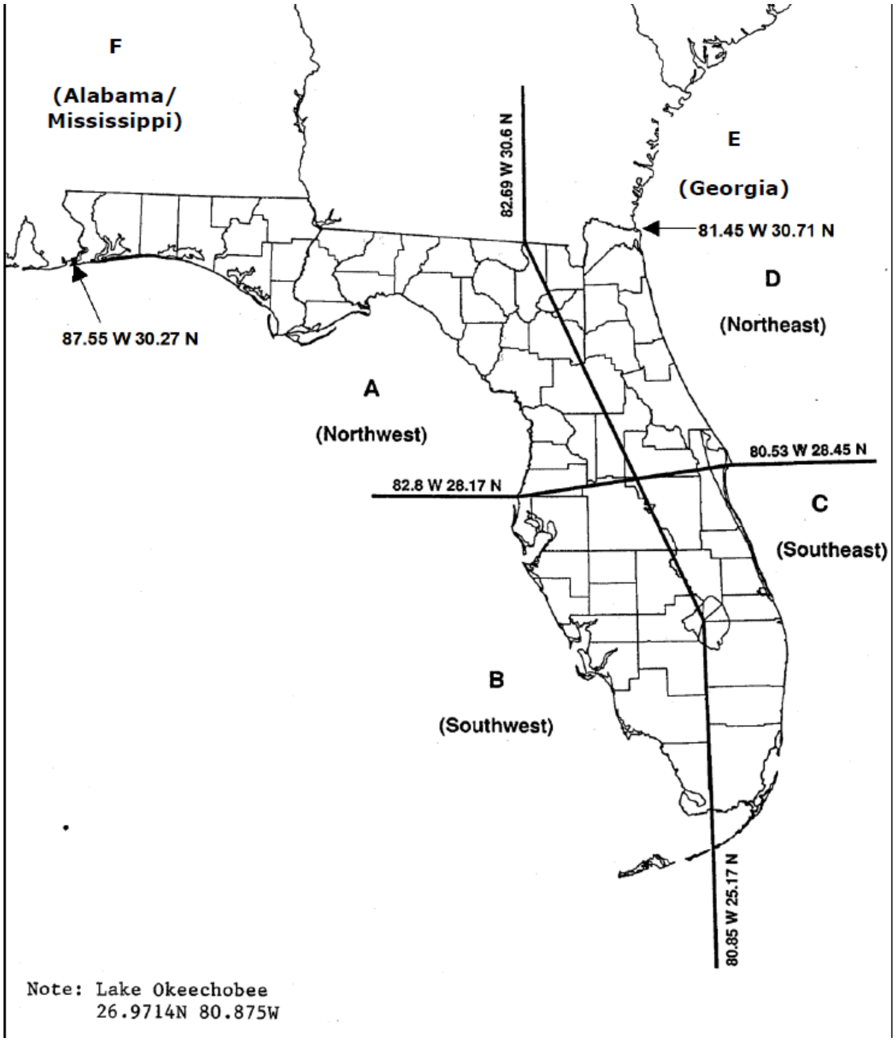
	Region D – NE Florida				Florida Bypassing Hurricanes			
	Historical		Modeled		Historical		Modeled	
Category	Number	Rate	Number	Rate	Number	Rate	Number	Rate
1	1	0.008	508	0.010	9	0.076	1842	0.037
2	1	0.008	229	0.005	3	0.025	1728	0.035
3	1	0.008	197	0.004	1	0.008	1572	0.031
4	0	0.000	92	0.002	3	0.025	667	0.013
5	0	0.000	7	0.000	0	0.000	142	0.003

	Region E – Georgia				Region F – Alabama/Mississippi			
	Historical		Modeled		Historical		Modeled	
Category	Number	Rate	Number	Rate	Number	Rate	Number	Rate
1	0	0.000	699	0.014	10	0.084	3729	0.075
2	2	0.017	317	0.006	2	0.017	1959	0.039
3	0	0.000	244	0.005	5	0.042	1586	0.032
4	0	0.000	89	0.002	0	0.000	710	0.014
5	0	0.000	13	0.000	1	0.008	74	0.001

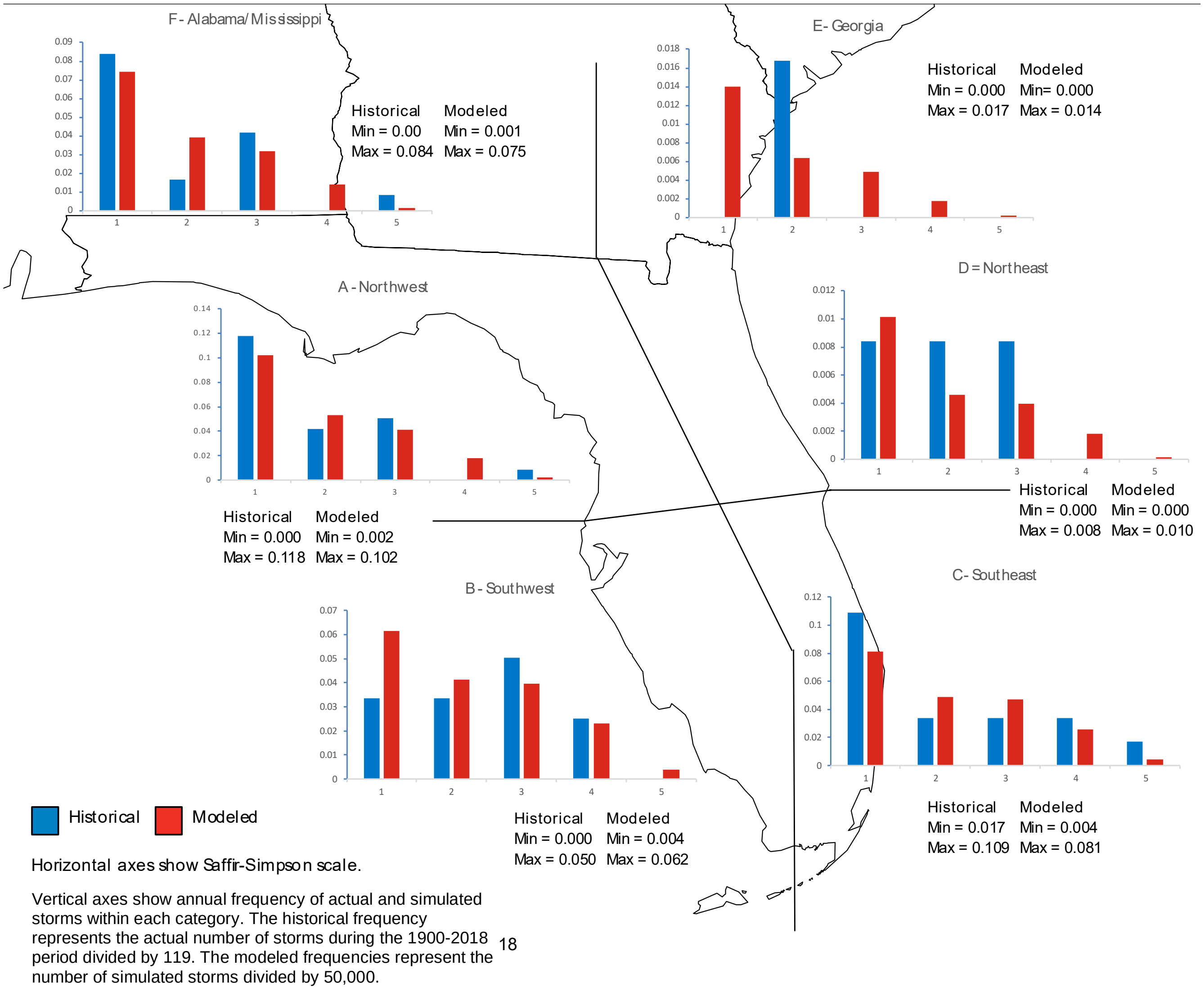
C. Describe hurricane model variations from the historical frequencies

The modeled frequencies are consistent with the historical frequencies for the period 1900–2018. There are no variations from these frequencies.

D. Provide vertical bar graphs depicting distributions of hurricane frequencies by category by region of Florida (Figure 3), 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.



ROA Figure 3: State of Florida and Neighboring States by Region



Horizontal axes show Saffir-Simpson scale.

Vertical axes show annual frequency of actual and simulated storms within each category. The historical frequency represents the actual number of storms during the 1900-2018 period divided by 119. The modeled frequencies represent the number of simulated storms divided by 50,000.

Figure 51. Historical and Modeled Hurricane Frequency for Florida and Neighboring States by Region

E. If the data are partitioned or modified, provide the historical annual occurrence rates for the applicable partition (and its complement) or modification as well as the modeled annual occurrence rates in additional copies of Form M-1, Annual Occurrence Rates.

The data has not been temporally partitioned or modified.

F. List all hurricanes added, removed, or modified from the previously-accepted hurricane model version of the Base Hurricane Storm Set.

Three recent storms (Hurricanes Irma and Nate in 2017 and Michael in 2018) were added to the base hurricane storm set. One storm, One storm, Able (1951), was modified according the recent update to HURDAT2.

The complete list of changes with impact on Florida is as follows:

Storms added: Irma-2017, Nate-2017, and Michael-2018

Storms modified: Able-1951

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, Annual Occurrence Rates, in a submission appendix.

This Form is included in this submission appendix item (Table 29. Modeled Annual Occurrence Rates) and is additionally provided in Excel format as AIR19FormM1.xlxs.

Form M-2: Maps of Maximum Winds

Standard M-4: Hurricane Windfield Structure

Notes for parts A, B, C:

Actual terrain is the roughness distribution used in the standard version of the hurricane model, as defined by the modeling organization. For the open terrain maps, the modeling organization shall apply a uniform roughness length of 0.03 meters at all land points, but keep the open-water points the same as the standard version of the hurricane model.

Maximum winds in these maps are defined as the maximum one-minute sustained winds over the terrain as modeled and recorded at each location.

The same color scheme and increments shall 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*	*White*
(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.

A. *Provide color-coded contour plots on maps with ZIP Code boundaries of the maximum winds for the modeled version of the Base Hurricane Storm Set for land use set for open terrain and for land use set for actual terrain. Plot the position and values of the maximum windspeeds on each contour map.*

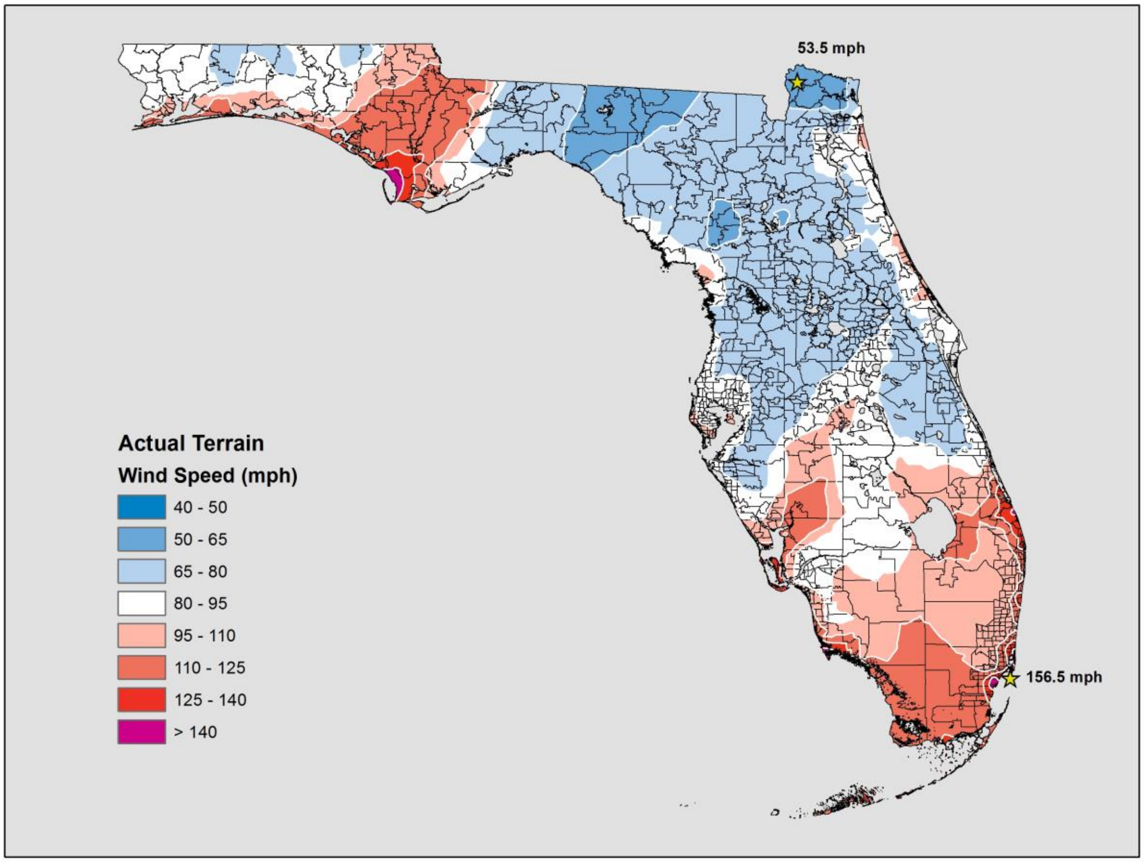


Figure 52. Maximum Winds for the Modeled Version of the Base Hurricane Storm Set for Actual Terrain

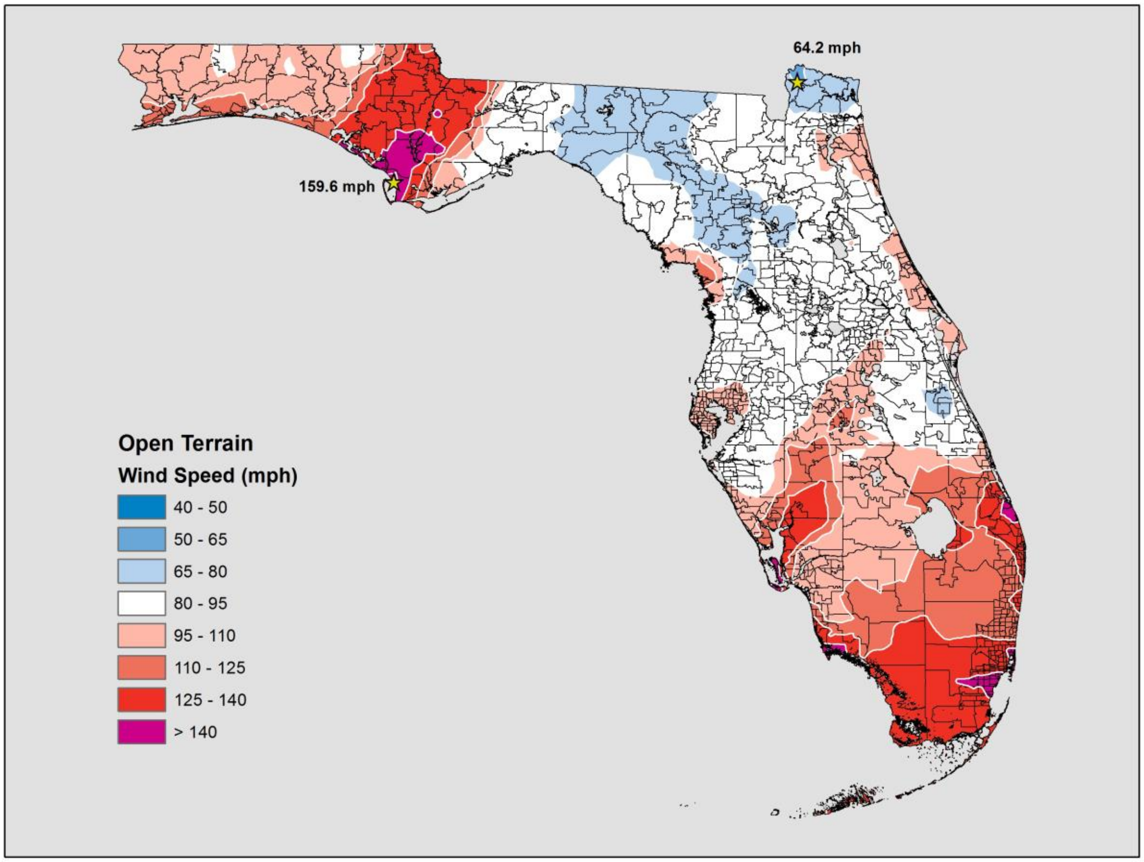


Figure 53. Maximum Winds for the Modeled Version of the Base Hurricane Storm Set for Open Terrain

B. 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 for land use set for open terrain and for land use set for actual terrain. Plot the position and values of the maximum windspeeds on each contour map.

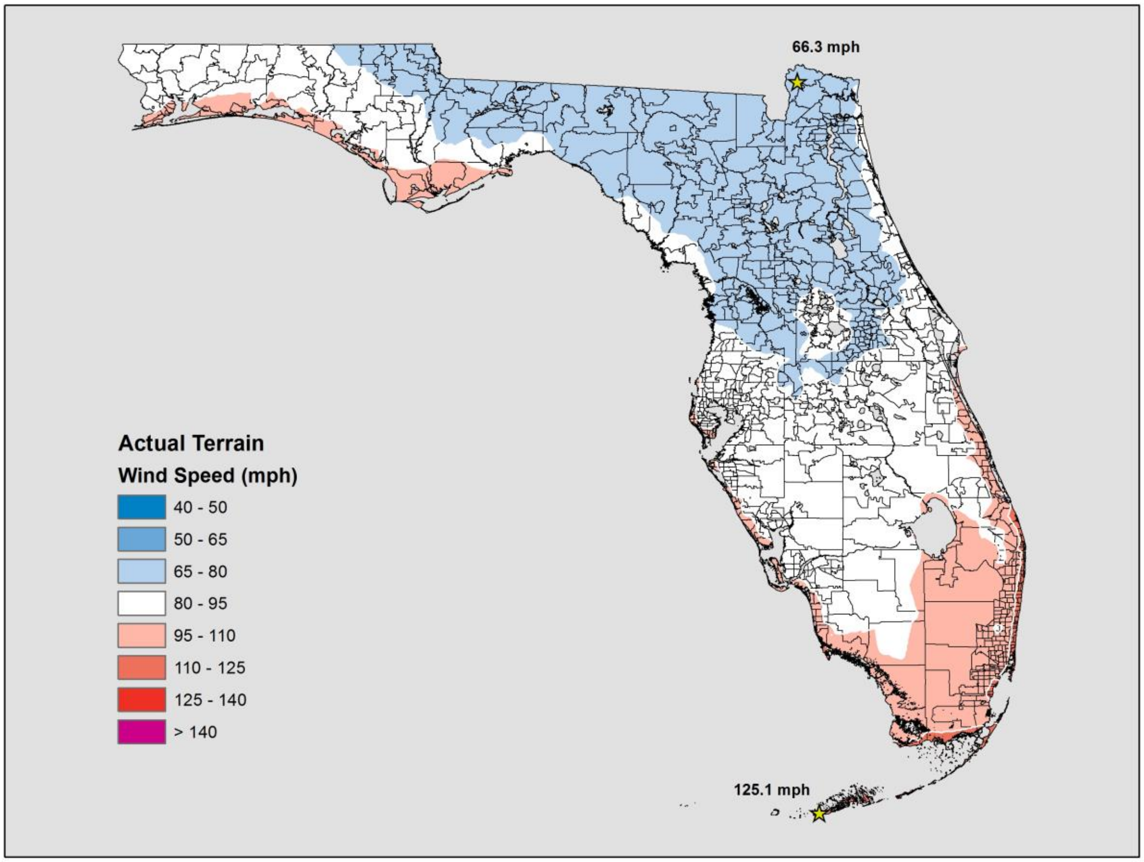


Figure 54. 100-Year Return Period Maximum Winds for Actual Terrain

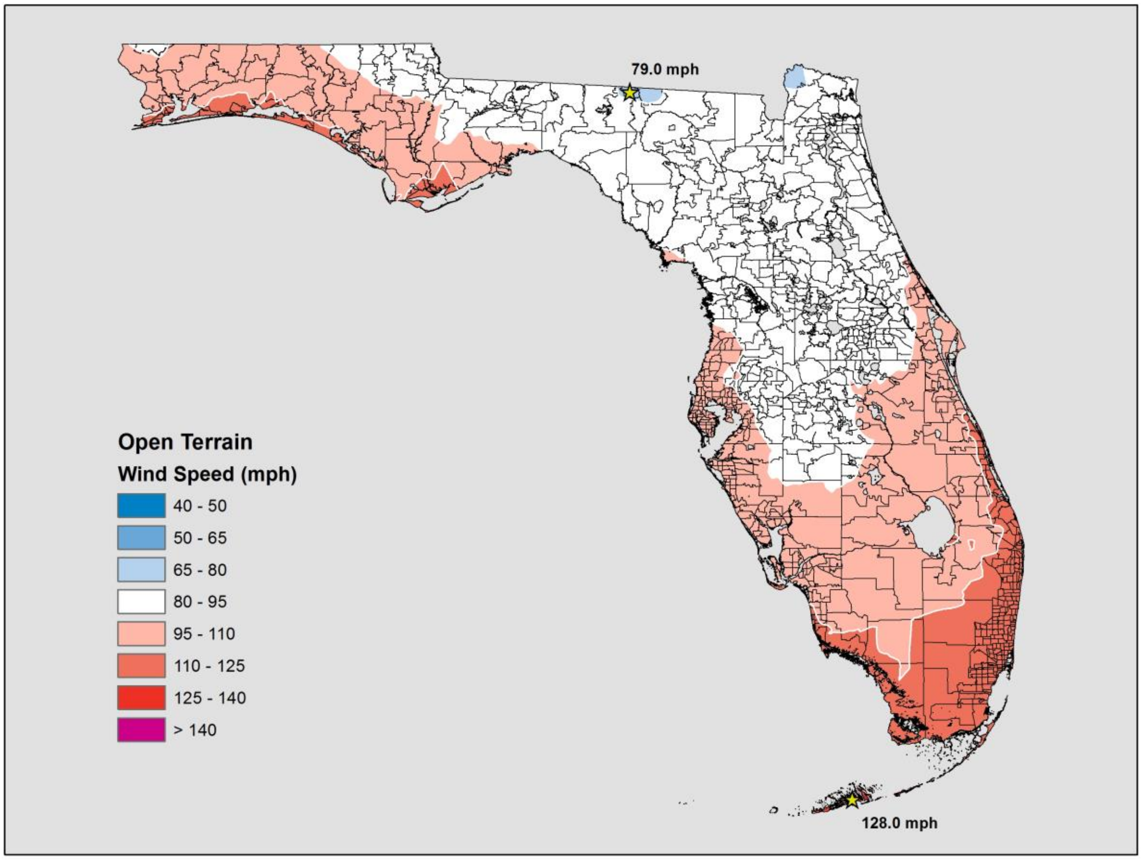


Figure 55. 100-Year Return Period Maximum Winds for Open Terrain

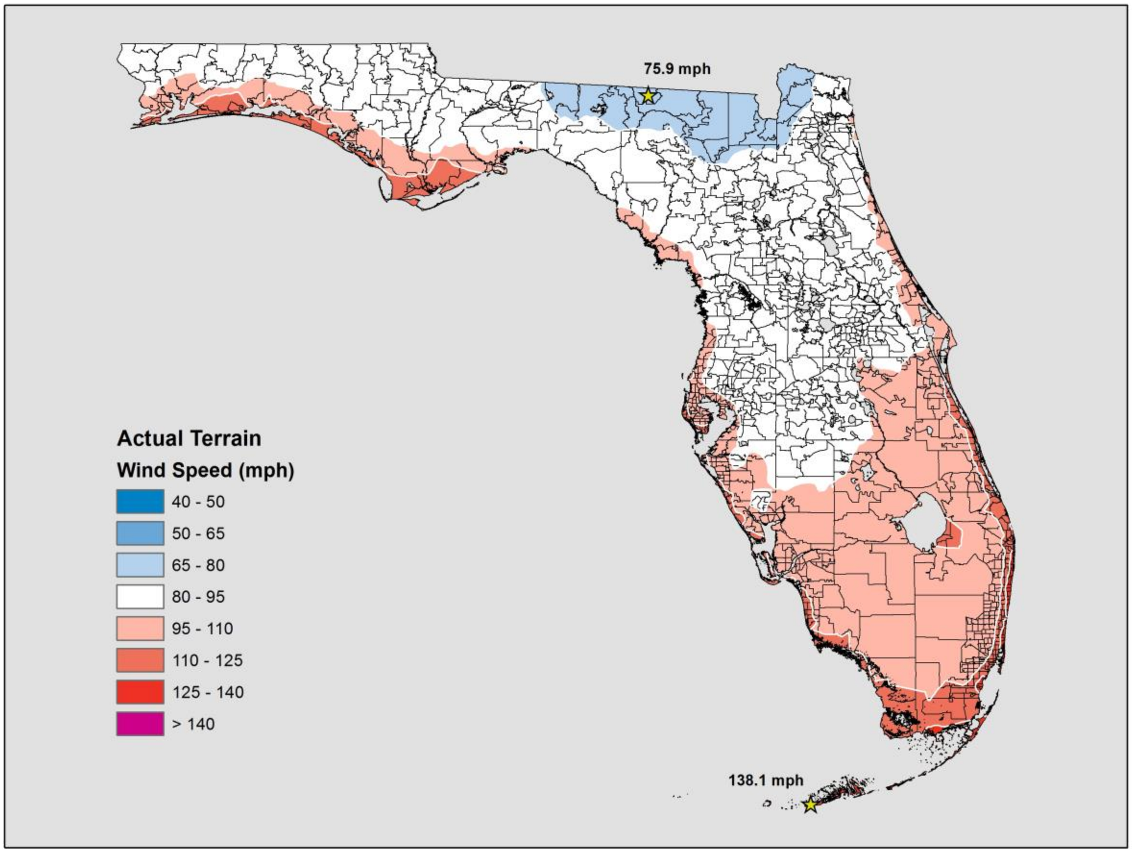


Figure 56. 250-Year Return Period Maximum Winds for Actual Terrain

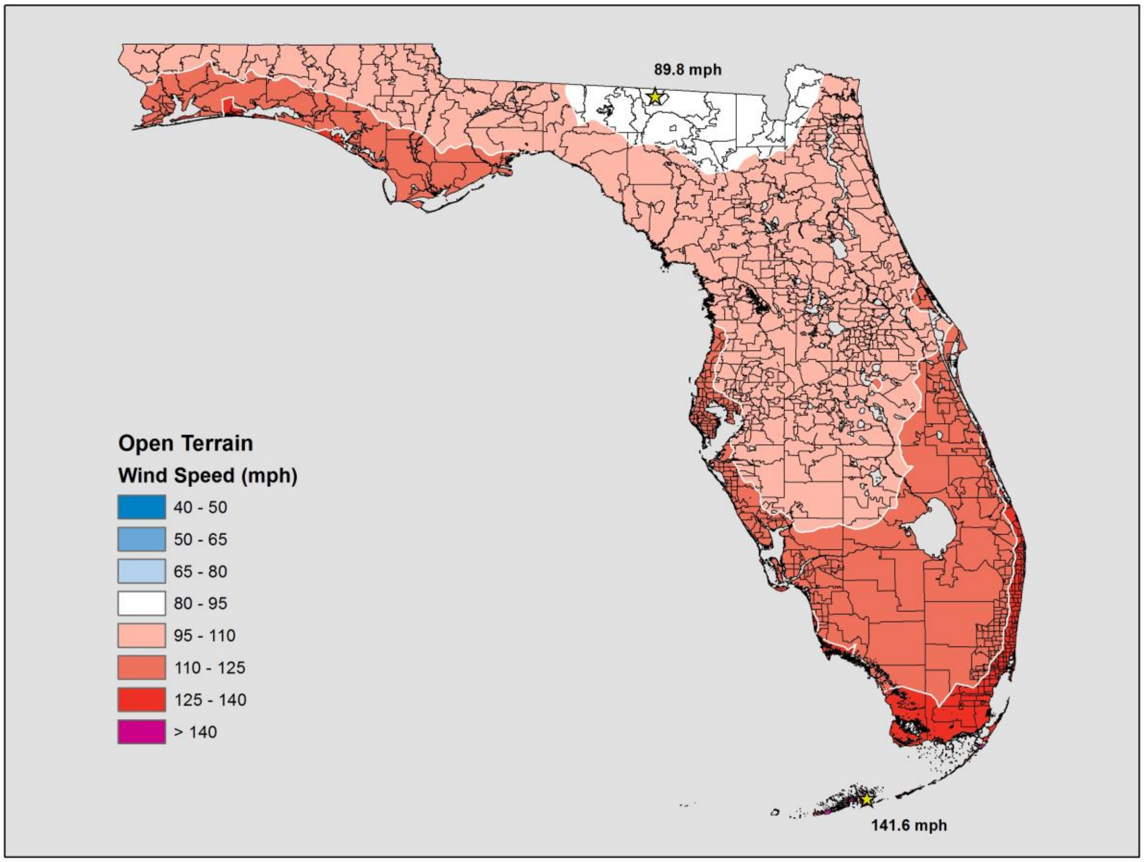


Figure 57. 250-Year Return Period Maximum Winds Open Terrain

C. Include Form M-2, Maps of Maximum Winds, in a submission appendix.

Included here in Figure 52 - Figure 57, per Disclosure 10 of Standard M-4: Hurricane Windfield Structure.

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

Standard M-6: Logical Relationships of Hurricane Characteristics

A. ***One or more automated programs or scripts shall be used to generate and arrange the data in Form M-3, Radius of Maximum Winds and Radii of Standard Wind Thresholds.***

Form M-3 Table 30 is generated from a Matlab script under source control.

B. ***For the central pressures in the table below, provide the first quartile (1Q), median (2Q), and third quartile (3Q) values for (1) the radius of maximum winds (Rmax) used by the hurricane model to create the stochastic storm set, and the first quartile (1Q), median (2Q), and third quartile (3Q) values for the outer radii of (2) Category 3 winds (>110 mph), (3) Category 1 winds (>73 mph), and (4) gale force winds (>40 mph).***

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
990	20	29	39	NA	NA	NA	17	25	35	73	96	114
980	20	28	36	31	31	33	27	37	47	99	122	137
970	17	24	31	20	32	32	29	41	52	112	131	147
960	17	25	32	14	21	31	35	50	60	129	149	162
950	17	25	29	17	25	32	37	53	66	133	155	172
940	14	23	27	19	26	30	34	50	60	128	150	168
930	14	24	27	20	31	37	41	57	70	137	162	178
920	15	21	29	23	30	39	47	58	78	144	162	190
910	14	16	20	24	27	32	46	60	69	140	162	174
900	7	8	18	13	16	30	31	34	57	116	120	157

C. ***Describe the procedure used to complete this form.***

For computing Rmax quartiles, cumulative distributions of Rmax in the historical catalog are calculated for central pressure bins centered on the values. Using the corresponding Rmax quartile values and the given central pressure, the model is used to compute quartiles of the significant wind radii. Representative values for other necessary parameters were assumed as follows: latitude (28°N), forward speed (28 mph), and gradient wind reduction factor (0.88). The model generates the radial wind profile for the given storm parameters, and then identifies the distance where this profile equals the requested wind speed thresholds (110 mph, 73 mph and 40 mph). Where winds never exceed the 110-mph threshold (in weaker storms), the table cell is left blank.

D. Identify other variables that influence Rmax.

The value of Rmax is a function of central pressure, latitude and time after landfall.

E. 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).

F. Provide a box plot and histogram of Central Pressure (x-axis) versus Rmax (y-axis) to demonstrate relative populations and continuity of sampled hurricanes in the stochastic storm set.

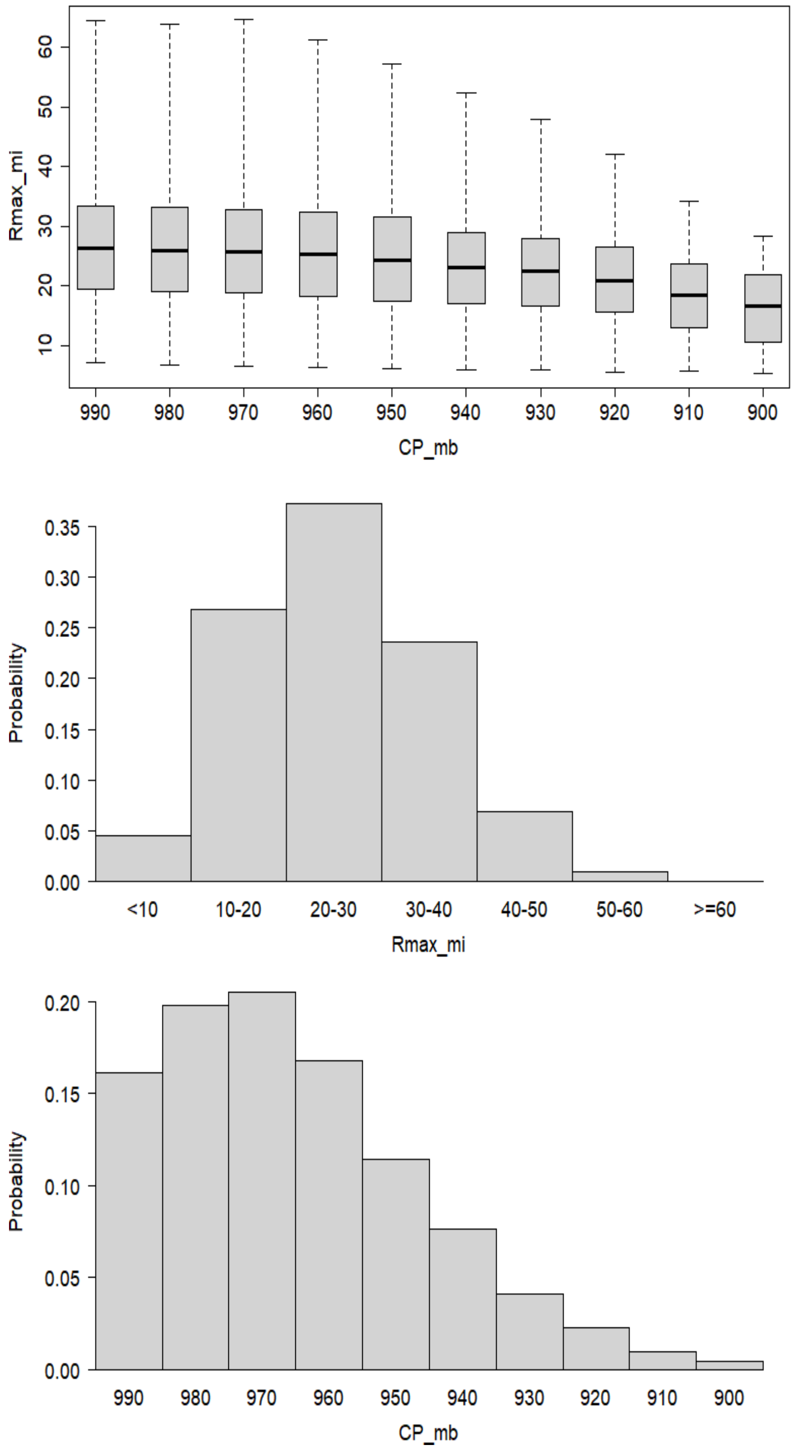


Figure 58. Box Plot and Histogram of Central Pressure vs. Rmax, Florida and Neighboring States

G. Provide this form in Excel using the format given in the file named "2019FormM3.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, Radius of Maximum Winds and Radii of Standard Wind Thresholds, in a submission appendix.

Hard copy of Form M-3 is included here in this submission appendix and is additionally provided in Excel format.

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

Link: Standard M-6: Logical Relationships of Hurricane Characteristics

Appendix 3: Statistical Standards

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

A. ***One or more automated programs or scripts shall be used to generate and arrange the data in Form S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year.***

An R package was created for the Florida Commission submission. Form S-1 was generated using this package.

B. ***Complete the table below showing the probability and modeled frequency of landfalling Florida hurricanes per year. Modeled probability shall be rounded to three decimal places. The historical probabilities and frequencies below have been derived from the Base Hurricane Storm Set for the 119-year period 1900-2018 (as given in Form A-2, Base Hurricane Storm Set Statewide Hurricane Losses). Exclusion of hurricanes that caused zero modeled Florida damage or additional Florida hurricane landfalls included in the modeling organization Base Hurricane Storm Set as identified in their response to Standard M-1, Base Hurricane Storm Set, shall be used to adjust the historical probabilities and frequencies provided.***

Table 31. Probability and Frequency of Florida Landfalling Hurricanes per Year, Hurricane Model Results

Hurricanes Per Year	Historical Probability	Modeled Probability	Historical Frequency	Modeled Frequency
0	0.613	0.557	73	27831
1	0.244	0.331	29	16571
2	0.118	0.089	14	4460
3	0.025	0.019	3	973
4	0	0.003	0	141
5	0	0.000	0	22
6	0	0.000	0	2
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10 or more	0	0	0	0

Standard S-1: Modeled Results and Goodness-of-Fit, Disclosure 7

C. If the data are partitioned or modified, provide the historical probabilities and frequencies for the applicable partition (and its complement) or modification as well as the modeled probabilities and frequencies in additional copies of Form S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year.

AIR uses HURDAT2 as the source for historical hurricane data as reported (i.e., not partitioned or modified) for model development and for historical probabilities and frequencies in Form S-1. Therefore, AIR does not have additional information to disclose.

D. Include Form S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year, in a submission appendix.

Included here as part of Standard S-1: Modeled Results and Goodness-of-Fit

Form S-2: Examples of Hurricane Loss Exceedance Estimates

A. ***One or more automated programs or scripts shall be used to generate and arrange the data in Form S-2, Examples of Hurricane Loss Exceedance Estimates.***

An R package was created for the Florida Commission submission. Form S-2 was generated using this package.

B. ***Provide estimates of the annual aggregate combined personal and commercial insured hurricane losses for various probability levels using the notional risk dataset specified in Form A-1, Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code, and using the 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data provided in the file named “hlpm2017c.zip.” 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.***

C. ***Include Form S-2, Examples of Hurricane Loss Exceedance Estimates (2017 FHCF Exposure Data), in a submission appendix.***

Table 32. Form S-2, Part A: Examples of Hurricane Loss Exceedance Estimates

Return Period (years)	Annual Probability of Exceedance	Estimated Hurricane Loss Notional Risk Dataset	Estimated Personal & Commercial Hurricane Residential Loss 2017 FHCF Dataset
Top Event	N/A	89,606,941	315,345,700,248
10,000	0.01%	81,849,370	252,096,253,135
5,000	0.02%	70,564,518	206,736,526,799
2,000	0.05%	55,929,903	159,813,982,077
1,000	0.10%	48,787,095	134,871,712,433
500	0.20%	44,014,227	108,245,486,723
250	0.40%	36,179,847	88,626,415,293
100	1.00%	26,199,344	59,428,024,077
50	2.00%	19,439,831	40,295,013,746
20	5.00%	11,060,484	20,423,736,644
10	10.00%	5,983,675	10,166,616,449
5	20.00%	2,356,350	3,593,292,660

Table 33. Form S-2, Part B: Examples of Hurricane Loss Exceedance Estimates

	Estimated Loss Notional Risk Dataset	Estimated Personal & Commercial Residential Loss 2017 FHCF Dataset
Mean (Total Average Annual Hurricane Loss)	2,055,720	3,936,379,209
Median	63,872	75,620,865
Standard Deviation	5,221,656	12,115,505,422
Interquartile Range	1,521,784	2,256,264,277
Sample Size	50,000 Years of Simulated Events	50,000 Years of Simulated Events

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

Form S-3: Distributions of Stochastic Hurricane Parameters

A. Provide the probability distribution functional form used for each stochastic hurricane parameter in the hurricane model. Provide a summary of the justification for each functional form selected for each general classification.

B. Include Form S-3, Distributions of Stochastic Hurricane Parameters, in a submission appendix.

Submitted here for Standard S-1: Modeled Results and Goodness-of-Fit, Disclosure 1

Table 34. Form S-3: Distributions of Stochastic Hurricane Parameters

Stochastic Hurricane Parameter (Function or Variable)	**Functional Form of Distribution**	**Data Source**	**Year Range Used**	**Justification for Functional Form**
Annual Frequency	Negative Binomial (s,p) s>0 0<p<1	HURDAT2	1900–2018	Appropriate for count data when the variance exceeds the mean. The Negative Binomial is also known as a gamma-Poisson mixture, since it can be derived from a Poisson where the annual rate follows a gamma distribution. These considerations, combined with goodness-of-fit results, justify the use of the Negative Binomial distribution for annual landfall frequency.
Landfall Location	Cumulative distribution function (CDF) derived by smoothing historical landfall frequencies grouped by 50-mile coastal segments	HURDAT2	1900–2018	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. Graphical comparisons and goodness-of-fit tests indicate that the resulting landfall distribution is reasonable.
Central Pressure	Weibull(k, λ) where k>0 is the shape parameter, and λ>0 is the scale parameter.	HURDAT	1900–2008	The distribution of the historical central pressures is a skewed distribution since very intense hurricanes are less frequent than weak hurricanes. The two-parameter Weibull distribution has a very flexible shape and is able to capture the skewness present in the historical data. Goodness-of-fit tests support the use of this distribution. A comparison to the Log-normal distribution was reported by Clark (1986).

Stochastic Hurricane Parameter (Function or Variable)	**Functional Form of Distribution**	**Data Source**	**Year Range Used**	**Justification for Functional Form**
Radius of Maximum Winds	Truncated normal distribution with mean Rmax modeled by using regression model of the form: Rmax = f(CP, latitude)	HURDAT	1900–2008	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.
Forward Speed	Log-normal(μ, σ) where μ is the mean and σ is the standard deviation	HURDAT	1900–2008	This distribution is well-suited to represent forward speed which has a skewed distribution. Graphical comparisons between historical and modeled forward speeds combined with goodness-of-fit tests support the use of the Log-normal distribution.
Gradient Wind Reduction Factor	Normal distribution	Dropsonde data analysis; Research by Franklin, et al. (2003) and Powell et al. (2009)	2002–2005 for dropsonde data	An analysis of the historical data shows a symmetrical distribution well approximated by a Normal distribution
Peak Weighting Factor	Skewed distribution modeled as a Normal Distribution after variable transformation	Dropsonde data analysis; Research by Powell et al. (2009)	2002–2005 for dropsonde data	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.
Storm Heading at Landfall	Mixture of normal distributions with constraints imposed on the drawings	HURDAT	1900–-2008	Modeled as combined Normal distributions, and bounded based on the historical record and orientation of the coast-line. Comparisons of historical and simulated tracks provide support for this procedure.

Stochastic Hurricane Parameter (Function or Variable)	**Functional Form of Distribution**	**Data Source**	**Year Range Used**	**Justification for Functional Form**
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	Time series models are appropriate since the storm parameters are typically correlated across time. 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 AIR for the Northwest Pacific basin; see Pawale, et. al. (2003).
Landfalling Calendar Date	Modeled using a Weibull distribution.	HURDAT2	1900-2006	The Weibull distribution has positive support and can accommodate skewed data.

Form S-4: Validation Comparisons

Standard S-5: Replication of Known Hurricane Losses

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. Also, specify the name of the hurricane event compared.

Notes: 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 should be the same hurricane parameters as used in completing Form A-2, Base Hurricane Storm Set Statewide Hurricane Losses.

*Note: All of the exposures and losses provided in the four examples provided below have been multiplied by a single constant to disguise the identity of the client.

Table 35. Form S-4, 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	9,003,772,462	6,881,690	0.00076	9,003,772,462	10,377,772	0.00115
Masonry	7,729,395,776	2,987,052	0.00039	7,729,395,776	4,482,609	0.00058
Manufactured Home	464,017,336	663,292	0.00143	464,017,336	3,242,002	0.00699
Total	**17,197,185,574**	**10,532,034**	**0.00061**	**17,197,185,574**	**18,102,383**	**0.00105**

Table 36. Form S-4, 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	1,819,446,786	9,755,813	0.00536	1,819,446,786	6,645,652	0.00365
Coverage C	1,023,515,089	772,325	0.00075	1,023,515,089	718,100	0.00070
Coverage D	165,166,384	239,072	0.00145	165,166,384	136,920	0.00083
Total	**3,008,128,259**	**10,767,210**	**0.00358**	**3,008,128,259**	**7,500,672**	**0.00249**

Table 37. Form S-4, 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	0.01241	4,913,776,098	36,680,859	0.00746
Masonry	3,523,834,122	57,537,128	0.01633	3,523,834,122	50,969,433	0.01446
Total	**8,437,610,220**	**118,520,285**	**0.01405**	**8,437,610,220**	**87,650,292**	**0.01039**

Table 38. Form S-4, 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	0.0190	6,796,595	190,373	0.0280
Martin	25,581,283	162,294	0.0063	25,581,283	177,023	0.0069
Okeechobee	11,486,384	107,558	0.0094	11,486,384	81,063	0.0071
Palm Beach	510,864,780	1,641,708	0.0032	510,864,780	2,563,143	0.0050
St. Lucie	25,341,432	149,397	0.0059	25,341,432	148,754	0.0059
Total	**580,070,474**	**2,190,358**	**0.0038**	**580,070,474**	**3,160,356**	**0.0054**

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 AIR occupancy code 306—commercial residential and includes reinforced concrete, masonry and wood frame constructions as defined in Table 12. The data also contains height information. The description of AIR height bands is given in Table 13.

Table 39. Comparison of Actual Commercial Residential Exposures and Loss to Modeled Exposure and Loss

Hurricane	Exposure ($)	Actual Loss ($)	Modeled Loss ($)
Charley	9,750,543,180	65,465,443	104,763,971
Frances	5,953,182,495	60,324,157	33,332,578
Ivan	769,935,738	22,407,198	23,429,217
Jeanne	6,270,282,204	11,708,119	24,733,277
Wilma	15,004,104,155	140,144,282	137,121,245
Katrina	8,098,990,923	7,139,327	12,402,655
Total	**45,847,038,695**	**307,188,526**	**335,782,943**

Note: All of the exposures and losses have been multiplied by a single constant to disguise the identity of clients.

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.)

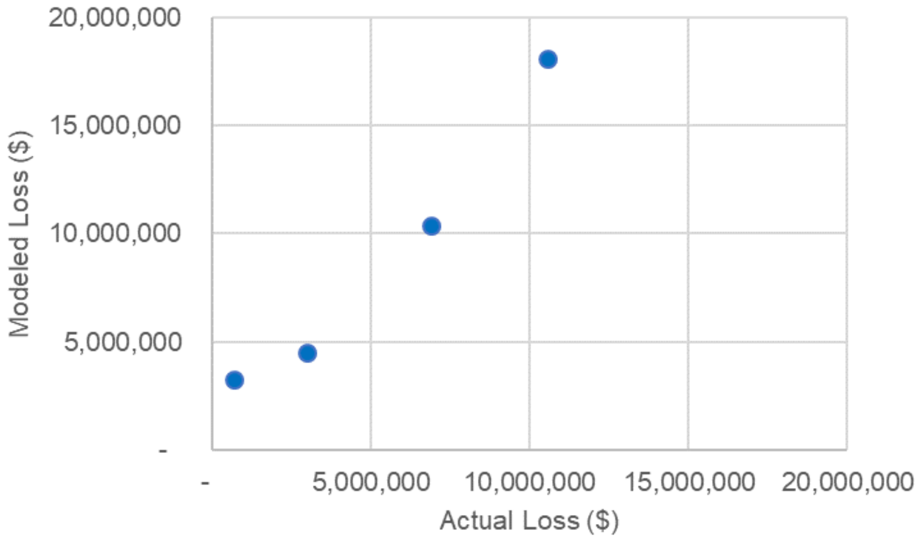


Figure 59. Scatter Plot of Comparison #1

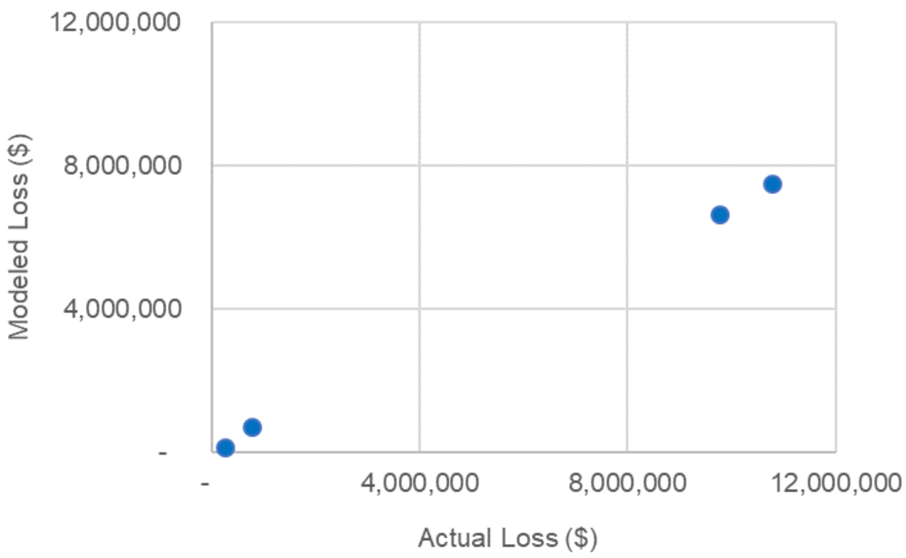


Figure 60. Scatter Plot of Comparison #2

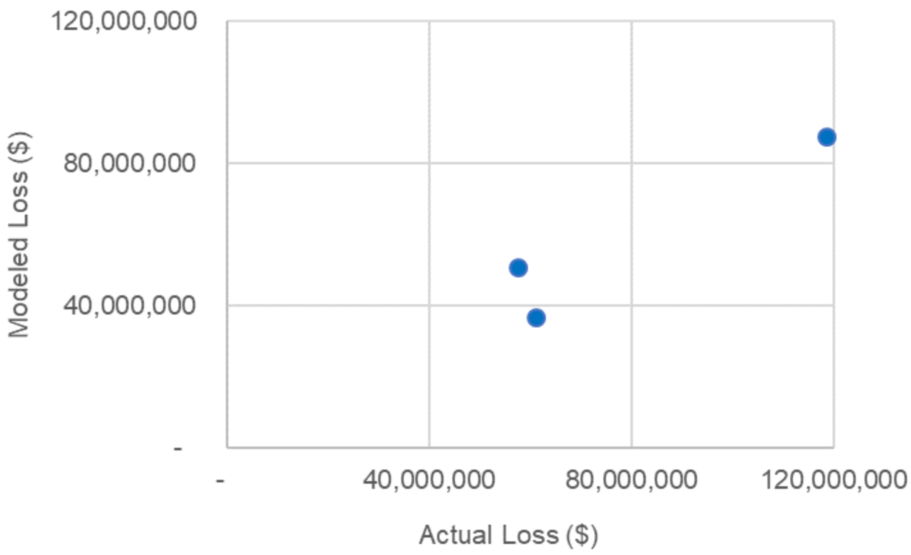


Figure 61. Scatter Plot of Comparison #3

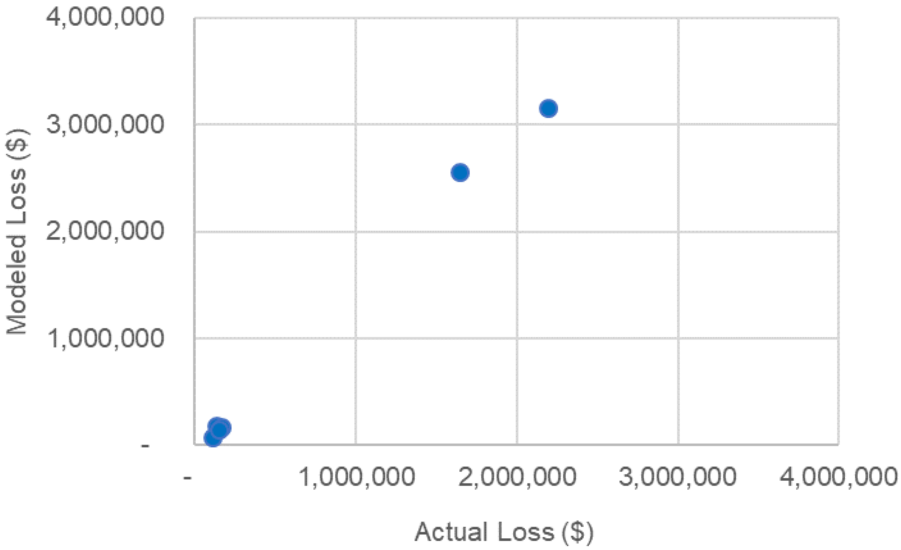


Figure 62. Scatter Plot of Comparison #4

D. Include Form S-4, Validation Comparisons, in a submission appendix.

Submitted here for Standard S-5: Replication of Known Hurricane Losses

Form S-5: Average Annual Zero Deductible Statewide Hurricane Loss Costs – Historical Versus Modeled

A. *Provide the average annual zero deductible statewide personal and commercial residential hurricane loss costs produced using the list of hurricanes in the Base Hurricane Storm Set as defined in Standard M-1, Base Hurricane Storm Set, based on the 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named "hlpm2017c.zip."*

The average annual zero deductible statewide personal and commercial residential loss costs produced using the list of hurricanes in M-1 based on the 2017 FHCF aggregate data has been provided in Table 40.

Table 40. Average Annual Zero Deductible Statewide Personal and Commercial Residential Hurricane Loss Costs

Time Period	Historical Hurricanes	Produced by Hurricane Model
Current Submission	3.198 billion	3.936 billion
Previously Accepted Hurricane Model* (2017 Hurricane Standards)	3.104 billion	3.919 billion
Percentage Change Current Submission/ Previously Accepted Hurricane Model*	3.05%	0.44%
Second Previously-Accepted Hurricane Model* (2015 Standards)	NA	NA
Percent Change Current Submission/ Second Previously-Accepted Hurricane Model*	NA	NA

**NA if no previously accepted hurricane model*

B. *Provide a comparison with the statewide personal and commercial residential hurricane loss costs produced by the hurricane model on an average industry basis.*

The average annual zero deductible statewide loss cost produced using the list of hurricanes in the Base Hurricane Storm Set and the 2017 FHCF aggregate personal and commercial residential exposure data is \$3.198 billion (μH). The statewide loss cost produced on an average industry basis is \$3.936 billion (μS).

C. *Provide the 95% confidence interval on the differences between the means of the historical and modeled personal and commercial residential hurricane loss costs.*

The 95% confidence interval on the difference between the mean historical and modeled losses is (-2.187 billion <= (μ_H - μ_S) <= +0.711 billion).

D. ***If the data are partitioned or modified, provide the average annual zero deductible statewide personal and commercial residential hurricane loss costs for the applicable partition (and its complement) or modification, as well as the modeled average annual zero deductible statewide personal and commercial residential hurricane loss costs in additional copies of Form S-5, Average Annual Zero Deductible Statewide Hurricane Loss Costs – Historical versus Modeled.***

The historical and modeled statewide average annual zero deductible statewide personal and commercial residential hurricane loss costs disclosed and evaluated in the above sections are output from the AIR model. The data has not been partitioned or modified in any way.

E. ***Include Form S-5, Average Annual Zero Deductible Statewide Hurricane Loss Costs – Historical versus Modeled, in a submission appendix.***

Standard S-6: Comparison of Projected Hurricane Loss Costs

Form S-6: Hypothetical Events for Sensitivity and Uncertainty Analysis

Form S-6 was submitted and accepted as a requirement under the 2009 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 Statistical Standards S-2 and S-3.

Appendix 4: Vulnerability Standards

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 "FormV1Input19.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.

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
Reference Manufactured Home Structure	**Reference Concrete Structure**
Tie downs Single unit Manufactured in 1980	Twenty story Eight apartment units per story No shutters Standard glass windows Constructed in 1980

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 shall 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.

Table 41. Damage Ratios Summarized by Windspeed (mph) and Construction Type

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
Part A			
41 – 50	0.054%	0.011%	0.000%
51 – 60	0.123%	0.026%	0.001%
61 – 70	0.462%	0.099%	0.007%
71 – 80	0.955%	0.202%	0.018%
81 – 90	1.888%	0.460%	0.047%
91 – 100	3.548%	0.992%	0.128%
101 – 110	7.342%	2.816%	0.525%
111 – 120	20.582%	14.880%	3.066%
121 – 130	32.752%	21.080%	4.935%
131 – 140	42.133%	29.515%	8.514%
141 – 150	54.190%	43.102%	14.505%
151 – 160	61.766%	50.133%	17.919%
161 – 170	71.705%	55.817%	21.867%

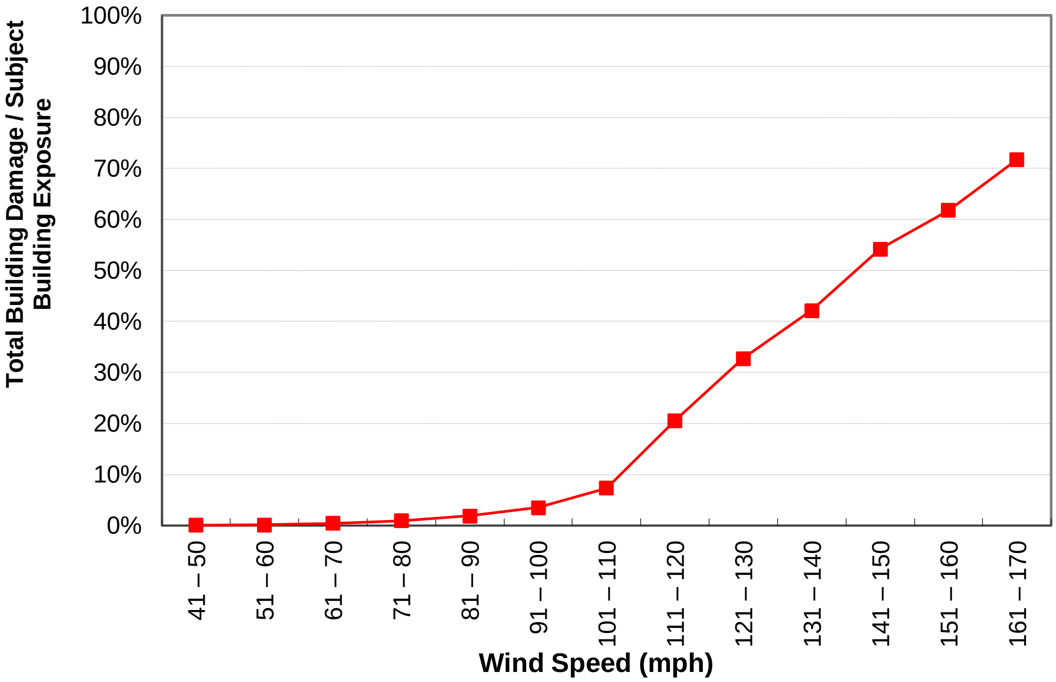
* Windspeeds are one-minute sustained, measured at ten-meter height

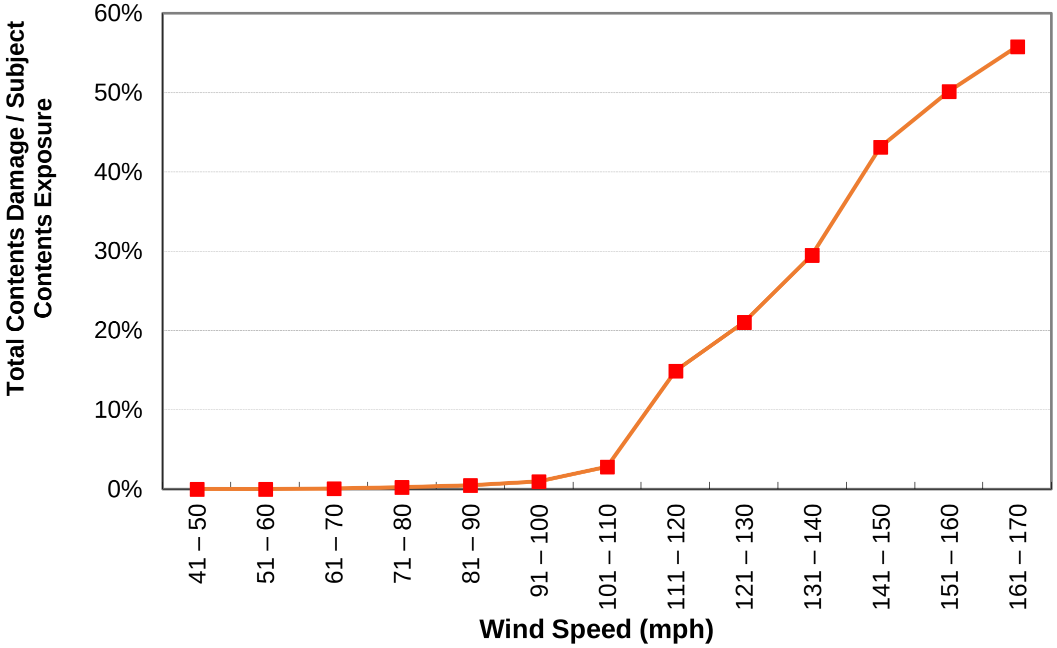
Construction Type	Estimated Building Damage/ Subject Building Exposure	Estimated Contents Damage/ Subject Exposure	Estimated Time Element Loss/ Subject Time Element Exposure
Part B			
Wood Frame	22.426%	17.573%	7.863%
Masonry	18.700%	14.928%	6.552%
Manufactured Home	34.498%	24.550%	5.316%
Concrete Structure	4.321%	3.429%	1.219%

B. Confirm that the structures used in completing the form are identical to those in the above table for the reference structures. If additional assumptions are necessary to complete this form (for example, regarding structural characteristics, duration, or surface roughness), provide the reasons why the assumptions were necessary as well as a detailed description of how they were included.

The structures used in completing this Form are identical to those in the above table. The AIR 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, the effect of duration is not accounted for. The ZIP Code-level maximum wind speeds provided in the file named FormV1Input19.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. The AIR Hurricane Model for the U.S. additionally considers actual terrain surface roughness to calculate the wind speeds used in Form V-1. 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.

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.





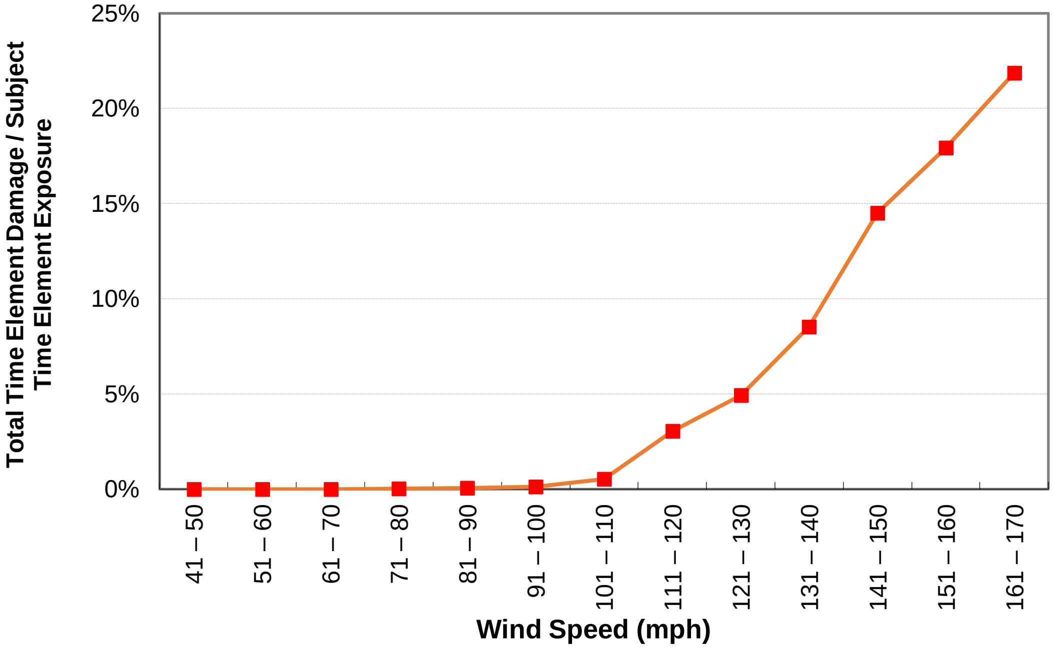


Figure 63. Loss percentages by wind speed for the building, contents, and time element data

D. Include Form V-1, One Hypothetical Event, in a submission appendix.

Included here as part of Standard V-1: Derivation of Building Hurricane Vulnerability Functions

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

A. ***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, 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.***

A completed Form V-2 is provided in this submission appendix.

B. ***If additional assumptions are necessary to complete this form (for example, regarding duration or surface roughness), provide the rationale for the assumptions as well as a detailed description of how they are included.***

The AIR 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, the effect of duration is not accounted for.

The instructions for Form V-2 require a wind speed input. Wind speed is not an explicit input to the AIR Hurricane Model for the U.S. To populate Form V-2, we create a set of events, which approximate the requested wind speeds at the specified locations.

Additionally, the reference frame and masonry structure are assumed to not have sliding glass doors.

C. ***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, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage, in a submission appendix.***

A hard copy of Form V-2 is included in this submission appendix item and is additionally provided in Excel format without truncation. The Excel file is named AIR_2019-2020_Form V-2.xlsx.

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
Reference Manufactured Home Structure	**Reference Concrete Structure**
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

Place the reference building at the population centroid for ZIP Code 33921 in Lee County.

Table 42. Mitigation measures--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		10.6	15.0	14.0	9.8	6.3	10.3	14.9	14.0	9.7	6.2
	HIP ROOF		14.5	19.0	17.6	13.1	9.1	14.1	18.7	17.4	13.1	8.8
ROOF COVERING	METAL		6.1	5.0	3.1	1.7	0.6	5.9	4.8	3.0	1.6	0.6
	ASTM D7158 CLASS H SHINGLES		10.6	7.8	4.5	2.3	1.1	10.3	7.5	4.3	2.3	1.1
	MEMBRANE		9.9	14.4	12.1	2.2	1.1	9.7	14.6	12.0	2.1	1.0
	NAILING OF DECK	8d	9.0	18.6	21.2	16.6	9.8	8.9	18.3	20.8	16.8	9.5
ROOF-WALL STRENGTH	CLIPS		1.6	5.5	10.8	11.4	7.4	1.6	5.2	10.4	11.2	7.2
	STRAPS		2.1	7.0	13.2	14.0	9.6	2.1	6.6	13.0	14.2	9.4
WALL-FLOOR STRENGTH	TIES OR CLIPS		0.0	0.4	0.5	2.5	6.9	0.0	0.4	0.5	2.4	6.8
	STRAPS		0.0	0.8	2.1	5.8	12.5	0.0	0.8	2.0	5.7	12.2
WALL-FOUNDATION STRENGTH	LARGER ANCHORS OR CLOSER SPACING		0.0	0.4	0.5	2.5	6.9	-	-	-	-	-
	STRAPS		0.0	0.8	2.1	5.8	12.5	-	-	-	-	-
	VERTICAL REINFORCING		-	-	-	-	-	0.0	1.0	2.1	6.5	14.9
OPENING PROTECTION	WINDOW SHUTTERS	STRUCTURAL WOOD PANEL	8.2	13.2	12.5	9.6	8.1	8.0	12.9	11.9	9.2	7.8
		METAL	8.2	13.2	12.5	9.6	8.1	8.0	12.9	11.9	9.2	7.8
	DOOR AND SKYLIGHT COVERS		1.6	3.9	4.9	4.7	4.4	1.6	3.7	4.6	4.5	4.2
WINDOW, DOOR, SKYLIGHT STRENGTH	WINDOWS	IMPACT RATED	11.9	19.1	19.0	16.0	13.8	11.2	18.4	18.3	15.9	13.3
	ENTRY DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	1.6	3.9	4.9	4.7	4.4	1.6	3.7	4.6	4.5	4.2
	GARAGE DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	2.3	4.2	3.5	2.0	1.4	2.6	4.4	3.6	2.1	1.4
	SLIDING GLASS DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	-0.2	-0.6	-0.8	-0.7	-0.5	-0.3	-0.6	-0.7	-0.7	-0.6
	SKYLIGHT	IMPACT RATED	1.3	1.6	1.4	0.9	0.6	1.4	1.6	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	33.5	49.2	52.6	42.6	27.2	32.1	47.0	50.5	41.7	26.7

*Windspeeds are one-minute sustained and 10-meter.

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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, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), 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.***

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, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), 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.***

C. ***If additional assumptions are necessary to complete this form (for example, regarding duration or surface roughness), provide the rationale for the assumptions as well as a detailed description of how they are included.***

D. ***Provide a graphical representation of the hurricane vulnerability curves for the reference building and the fully mitigated building.***

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
Reference Manufactured Home Structure	**Reference Concrete Structure**
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

Place the reference building at the population centroid for ZIP Code 33921 in Lee County.

Windspeeds used in the form are one-minute sustained 10-meter windspeeds.

E. 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. Also include Form V-3, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), in a submission appendix.

Form V-3 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

A. *Provide the differences between the values reported in Form V-2, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage, relative to the equivalent data compiled from the previously-accepted hurricane model.*

A completed Form V-4 is provided in this submission appendix.

B. *Provide a list and describe any assumptions made to complete this form.*

All assumptions described in Form V-2B are applicable to Form V-4.

C. *Provide a summary description of the differences.*

Form V-4 is populated by taking a difference between Form V-2 in the current submission and its counterpart in the previous submission in accordance with the Report of Activities 2017-2018. The differences reported in Form V-4 mainly stem from the fact that the mean damage ratios calculated for the reference and mitigated frame and masonry buildings in the current submission versus the previous submission are slightly different for the reference wind speeds provided in this form. As stated in the assumptions for Form V-2, wind speed is not an explicit input to the AIR Hurricane Model for the U.S. To populate Form V-2, we create a set of events, which approximate the requested wind speeds at the specified locations. These wind speeds that are simulated in this current submission are slightly different from their previous submission counterparts leading to slight differences in the mean damage ratios for the reference and mitigated frame and masonry buildings.

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, Differences in Hurricane Mitigation Measures and Secondary Characteristics, in a submission appendix.*

A hard copy of Form V-4 is included in this submission appendix and is additionally provided in Excel format without truncation. The Excel file is titled “AIR_2019-2020_FormV-4.xlsx”.

Table 43. 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		-0.2	0.0	0.2	0.6	1.2	-0.4	-0.1	0.2	0.3	0.2
	HIP ROOF		-0.3	0.0	0.2	0.7	1.2	-0.3	0.0	0.2	0.5	0.3
ROOF COVERING	METAL		0.1	0.1	0.1	-0.1	0.3	-0.1	0.1	0.1	0.0	0.1
	ASTM D7158 CLASS H SHINGLES		0.2	0.2	0.1	0.0	0.5	0.0	0.2	0.1	0.0	0.1
	MEMBRANE		0.1	0.1	0.6	0.0	0.5	0.0	0.1	0.7	0.0	0.1
	NAILING OF DECK	8d	-0.4	-0.3	0.1	0.9	1.5	-0.4	-0.3	0.1	0.7	0.6
ROOF-WALL STRENGTH	CLIPS		0.0	-0.3	-0.2	0.6	1.4	-0.1	-0.2	-0.2	0.2	0.4
	STRAPS		0.0	-0.3	-0.2	0.6	1.4	-0.2	-0.3	-0.2	0.4	0.5
WALL-FLOOR STRENGTH	TIES OR CLIPS		0.0	0.0	-0.1	-0.3	0.6	0.0	0.0	-0.1	-0.3	-0.3
	STRAPS		0.0	0.0	-0.1	-0.3	0.5	0.0	0.0	-0.1	-0.5	-0.4
WALL-FOUNDATION STRENGTH	LARGER ANCHORS OR CLOSER SPACING		0.0	0.0	-0.1	-0.3	0.6	-	-	-	-	-
	STRAPS		0.0	0.0	-0.1	-0.3	0.5	-	-	-	-	-
	VERTICAL REINFORCING		-	-	-	-	-	-0.1	0.0	-0.1	-0.5	-0.5
OPENING PROTECTION	WINDOW SHUTTERS	STRUCTURAL WOOD PANEL	-0.3	-0.1	0.1	0.4	1.1	-0.2	0.0	0.1	0.1	0.1
		METAL	-0.3	-0.1	0.1	0.4	1.1	-0.2	0.0	0.1	0.1	0.1
	DOOR AND SKYLIGHT COVERS		0.0	-0.1	0.0	0.0	1.1	-0.1	-0.1	0.0	-0.1	0.1
WINDOW, DOOR, SKYLIGHT STRENGTH	WINDOWS	IMPACT RATED	-0.3	-0.1	0.1	0.7	1.2	-0.4	-0.1	0.1	0.4	0.3
	ENTRY DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	0.0	-0.1	0.0	0.0	1.1	-0.1	-0.1	0.0	-0.1	0.1
	GARAGE DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	-0.1	0.0	0.1	-0.1	0.6	-0.2	0.0	0.1	0.0	0.0
	SLIDING GLASS DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	0.0	0.0	0.0	0.1	-0.1	0.0	0.0	0.0	0.0	0.0
	SKYLIGHT	IMPACT RATED	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0

HURRICANE MITIGATION MEASURES AND SECONDARY CHARACTERISTICS IN COMBINATION	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
MITIGATED BUILDING	-0.5	-0.4	0.3	1.5	1.9	-0.6	-0.4	0.2	1.1	1.1

*Windspeeds are one-minute sustained 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, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), relative to the equivalent data compiled from the previously-accepted hurricane model.***

B. ***Provide a list and describe any assumptions made to complete this form.***

C. ***Provide a summary description of the differences.***

D. ***If not considered as Trade Secret, 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 V-5, Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), in a submission appendix.***

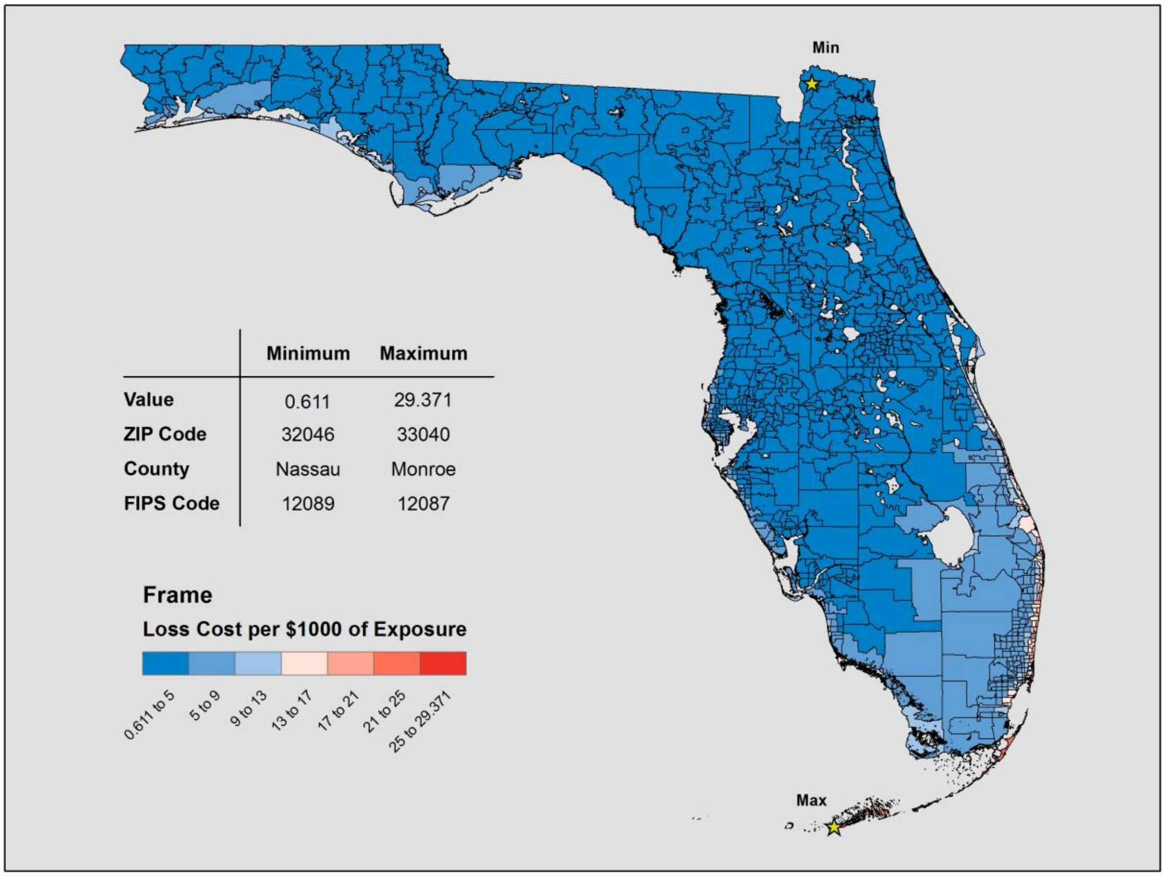
Form V-5 is considered trade secret and will be presented to the Professional Team and at the closed meeting of the Commission for review.

Appendix 5: Actuarial Standards

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

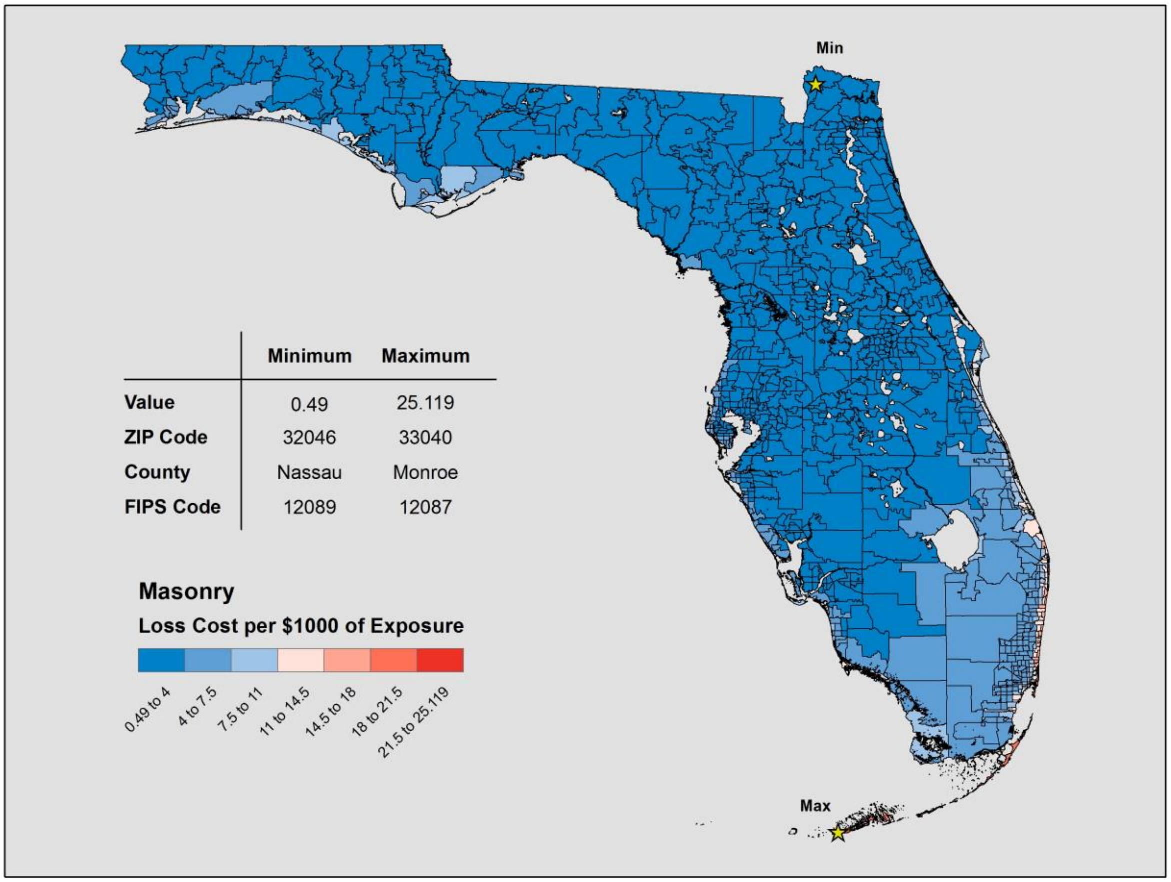
Purpose: This form and the associated maps illustrate the range and variation by ZIP Code of zero deductible hurricane loss costs across Florida separately for frame owners, masonry owners, and manufactured homes.

A. ***Provide three maps, color-coded by ZIP Code (with a minimum of six value ranges), displaying zero deductible personal residential hurricane loss costs per $1,000 of exposure for frame owners, masonry owners, and manufactured homes.***



	Minimum	Maximum
Value	0.611	29.371
ZIP Code	32046	33040
County	Nassau	Monroe
FIPS Code	12089	12087

Figure 64. Loss Costs by ZIP Code for Owners Wood Frame, Zero Deductible



	Minimum	Maximum
Value	0.49	25.119
ZIP Code	32046	33040
County	Nassau	Monroe
FIPS Code	12089	12087

Figure 65. Loss Costs by ZIP Code for Owners Masonry, Zero Deductible

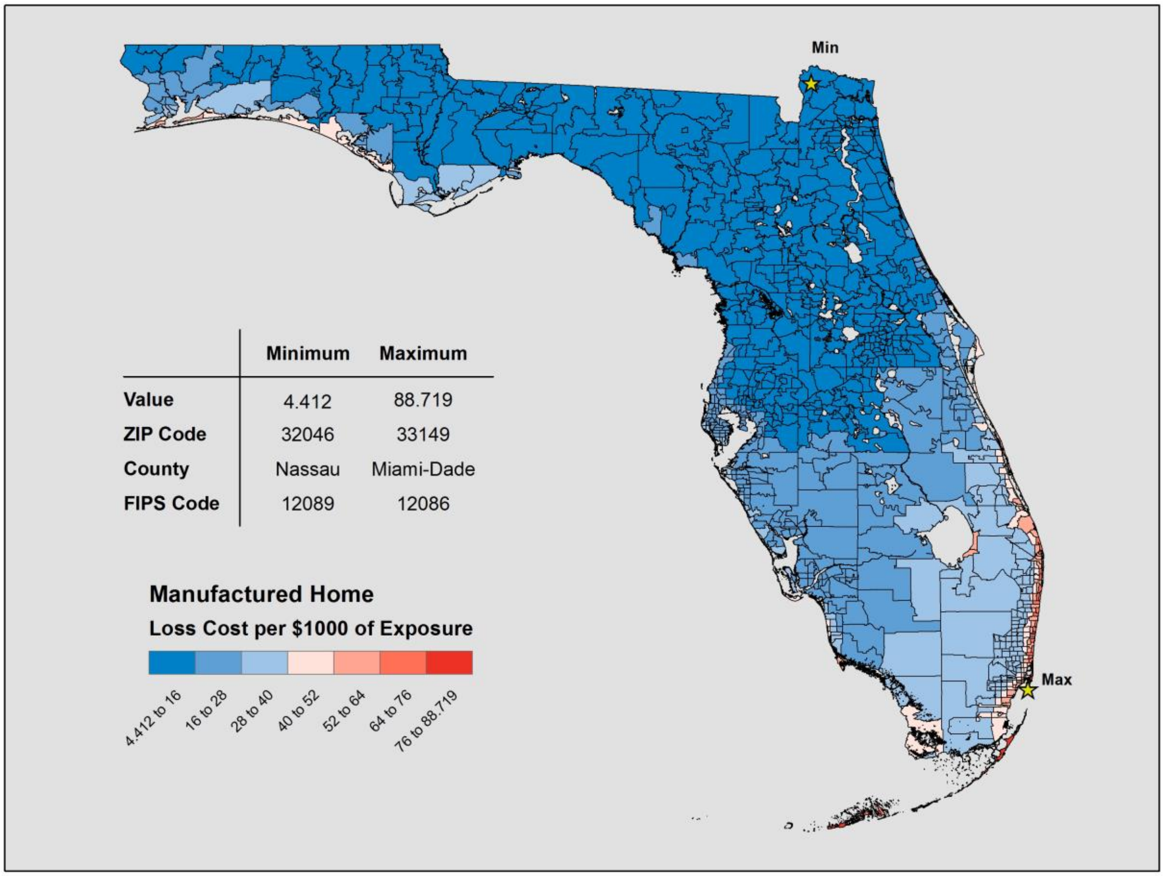


Figure 66. Loss Costs by ZIP Code for Manufactured Home, Zero Deductible

B. Create exposure sets for these exhibits by modeling all of the buildings from Notional Set 3 described in the file "NotionalInput19.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 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.

Notional Hurricane Policy Specifications

Policy Type: Owners
Assumptions

Coverage A = Building

- *Replacement Cost included subject to Coverage A limit*
- *Law and Ordinance included*

Coverage B = Appurtenant Structure

- *Replacement Cost included subject to Coverage B limit*

- *Law and Ordinance included*

Coverage C = Contents

- *Replacement Cost included subject to Coverage C limit*

Coverage D = Time Element

- *Time limit = 12 months*
- *Per diem = $150.00/day per policy, if used*

** Hurricane loss costs per $1,000 shall be related to the Coverage A limit*

Policy Type: Manufactured Homes
Assumptions

Coverage A = Building

- *Replacement Cost included subject to Coverage A limit*

Coverage B = Appurtenant Structure

- *Replacement Cost included subject to Coverage B limit*

Coverage C = Contents

- *Replacement Cost included subject to Coverage C limit*

Coverage D = Time Element

- *Time limit = 12 months*
- *Per diem = $150.00/day per policy, if used*

** Hurricane loss costs per $1,000 shall be related to the Coverage A limit*

Exposure sets for these exhibits have been created as specified.

C. Provide, in the format given in the file named "2019FormA1.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 shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name.

A completed Form A-1 is provided in both Excel and PDF formats. Form A-1 was prepared using an automated process designed to limit the amount of manual intervention and decrease time and diligence. During the automation process, AIR exercised due diligence verifying that the process produced the same indications for Form A-1 as completed in prior submissions.

Table 44. Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

See below

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

			Hurricane Lost Cost per Policy Type		
ZIP Code	**County Name**	**FIPS Code**	**Frame Owners**	**Masonry Owners**	**Manufactured Homes**
32601	Alachua	001	1.005	0.805	6.874
32603	Alachua	001	0.993	0.796	6.801
32605	Alachua	001	0.966	0.774	6.635
32606	Alachua	001	1.013	0.813	6.891
32607	Alachua	001	1.028	0.825	6.981
32608	Alachua	001	1.052	0.844	7.137
32609	Alachua	001	0.975	0.781	6.689
32610	Alachua	001	1.006	0.807	6.879
32611	Alachua	001	1.000	0.802	6.842
32612	Alachua	001	1.010	0.810	6.892
32615	Alachua	001	0.970	0.778	6.621
32618	Alachua	001	1.220	0.980	8.050
32631	Alachua	001	1.003	0.804	6.922
32641	Alachua	001	0.999	0.800	6.838
32643	Alachua	001	1.050	0.845	6.969
32653	Alachua	001	0.963	0.772	6.615
32669	Alachua	001	1.180	0.948	7.777
32694	Alachua	001	0.968	0.776	6.660
32040	Baker	003	0.679	0.545	4.830
32063	Baker	003	0.696	0.559	4.899
32087	Baker	003	0.624	0.500	4.505
32401	Bay	005	6.057	4.935	29.360
32403	Bay	005	10.733	8.877	43.571
32404	Bay	005	3.858	3.116	20.940
32405	Bay	005	4.923	3.994	25.454
32407	Bay	005	10.428	8.599	43.573
32408	Bay	005	11.234	9.294	45.701
32409	Bay	005	3.199	2.581	18.186
32413	Bay	005	10.467	8.646	43.486
32438	Bay	005	2.283	1.838	14.058
32444	Bay	005	3.743	3.028	20.719
32466	Bay	005	2.615	2.108	15.482
32044	Bradford	007	0.936	0.751	6.441
32058	Bradford	007	0.829	0.665	5.762
32091	Bradford	007	0.921	0.739	6.312
32622	Bradford	007	0.900	0.722	6.214

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type		
			Frame Owners	Masonry Owners	Manufactured Homes
00042	Brevard	009	3.549	2.851	21.343
32754	Brevard	009	2.904	2.335	17.545
32780	Brevard	009	3.043	2.448	18.389
32796	Brevard	009	3.033	2.440	18.289
32815	Brevard	009	3.652	2.948	21.333
32901	Brevard	009	6.663	5.433	32.373
32903	Brevard	009	10.850	8.976	45.140
32904	Brevard	009	4.293	3.461	24.118
32905	Brevard	009	6.854	5.595	32.888
32907	Brevard	009	3.569	2.869	21.220
32908	Brevard	009	3.543	2.847	21.190
32909	Brevard	009	3.892	3.132	22.624
32920	Brevard	009	8.120	6.671	38.576
32922	Brevard	009	3.683	2.971	21.369
32925	Brevard	009	9.964	8.273	43.092
32926	Brevard	009	3.142	2.529	18.900
32927	Brevard	009	3.050	2.454	18.390
32931	Brevard	009	9.195	7.595	41.868
32934	Brevard	009	4.339	3.499	24.241
32935	Brevard	009	5.618	4.554	28.992
32937	Brevard	009	10.174	8.449	43.265
32940	Brevard	009	4.762	3.855	25.657
32949	Brevard	009	8.501	6.980	38.129
32950	Brevard	009	7.355	6.013	34.475
32951	Brevard	009	11.806	9.824	47.885
32952	Brevard	009	5.257	4.290	27.384
32953	Brevard	009	4.052	3.281	22.963
32955	Brevard	009	4.357	3.522	24.223
32976	Brevard	009	9.289	7.639	40.624
00041	Broward	011	6.642	5.356	35.735
33004	Broward	011	16.501	13.728	62.439
33009	Broward	011	18.328	15.300	67.137
33019	Broward	011	20.083	16.891	71.334
33020	Broward	011	15.574	12.911	60.436
33021	Broward	011	9.206	7.484	43.874
33023	Broward	011	7.377	5.959	38.097

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type Frame Owners	Masonry Owners	Manufactured Homes
33024	Broward	011	6.463	5.209	34.875
33025	Broward	011	6.430	5.182	34.748
33026	Broward	011	6.378	5.140	34.644
33027	Broward	011	6.597	5.318	35.483
33028	Broward	011	6.584	5.305	35.491
33029	Broward	011	6.678	5.387	35.747
33060	Broward	011	14.983	12.407	59.527
33062	Broward	011	19.235	16.184	69.474
33063	Broward	011	6.283	5.062	34.323
33064	Broward	011	15.098	12.499	60.001
33065	Broward	011	6.329	5.101	34.561
33066	Broward	011	7.022	5.672	37.036
33067	Broward	011	6.261	5.044	34.311
33068	Broward	011	6.267	5.049	34.214
33069	Broward	011	8.435	6.845	41.632
33071	Broward	011	6.314	5.087	34.470
33073	Broward	011	6.505	5.244	35.264
33076	Broward	011	6.336	5.108	34.657
33301	Broward	011	16.456	13.692	62.573
33304	Broward	011	17.381	14.478	64.965
33305	Broward	011	16.492	13.710	63.064
33306	Broward	011	18.515	15.439	68.018
33308	Broward	011	18.785	15.678	68.869
33309	Broward	011	8.039	6.510	40.296
33311	Broward	011	9.120	7.410	43.632
33312	Broward	011	9.136	7.424	43.639
33313	Broward	011	6.321	5.094	34.397
33314	Broward	011	6.496	5.238	35.051
33315	Broward	011	13.022	10.735	54.036
33316	Broward	011	18.054	15.129	66.390
33317	Broward	011	6.403	5.161	34.712
33319	Broward	011	6.269	5.052	34.198
33321	Broward	011	6.281	5.061	34.324
33322	Broward	011	6.292	5.069	34.354
33323	Broward	011	6.349	5.115	34.658
33324	Broward	011	6.273	5.053	34.296

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type		
			Frame Owners	Masonry Owners	Manufactured Homes
33325	Broward	011	6.355	5.119	34.723
33326	Broward	011	6.447	5.195	35.126
33327	Broward	011	6.440	5.193	35.089
33328	Broward	011	6.265	5.048	34.223
33330	Broward	011	6.337	5.103	34.616
33331	Broward	011	6.505	5.241	35.284
33332	Broward	011	6.536	5.269	35.380
33334	Broward	011	14.162	11.702	57.430
33351	Broward	011	6.301	5.077	34.378
33441	Broward	011	17.213	14.321	65.316
33442	Broward	011	9.325	7.584	44.612
32421	Calhoun	013	1.703	1.370	10.863
32424	Calhoun	013	1.711	1.377	10.748
32430	Calhoun	013	1.804	1.452	11.400
32449	Calhoun	013	2.170	1.747	13.094
33946	Charlotte	015	8.436	7.031	35.484
33947	Charlotte	015	5.876	4.830	27.628
33948	Charlotte	015	3.796	3.088	19.976
33950	Charlotte	015	4.255	3.456	22.335
33952	Charlotte	015	3.608	2.919	19.677
33953	Charlotte	015	3.139	2.541	17.254
33954	Charlotte	015	3.203	2.579	18.273
33955	Charlotte	015	4.354	3.514	23.811
33980	Charlotte	015	3.400	2.742	19.208
33981	Charlotte	015	4.071	3.306	21.081
33982	Charlotte	015	3.042	2.441	18.405
33983	Charlotte	015	3.150	2.531	18.618
34224	Charlotte	015	5.961	4.895	27.947
34428	Citrus	017	1.899	1.529	11.519
34429	Citrus	017	1.928	1.556	11.456
34433	Citrus	017	1.587	1.274	10.105
34434	Citrus	017	1.608	1.291	10.203
34436	Citrus	017	1.676	1.346	10.646
34442	Citrus	017	1.663	1.339	10.400
34445	Citrus	017	1.672	1.343	10.504
34446	Citrus	017	1.842	1.482	11.203

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type Frame Owners	Masonry Owners	Manufactured Homes
34448	Citrus	017	1.975	1.593	11.542
34450	Citrus	017	1.713	1.377	10.844
34452	Citrus	017	1.707	1.371	10.737
34453	Citrus	017	1.639	1.319	10.314
34461	Citrus	017	1.657	1.331	10.372
34465	Citrus	017	1.608	1.291	10.181
32003	Clay	019	1.144	0.919	7.507
32043	Clay	019	1.038	0.833	6.997
32065	Clay	019	0.926	0.743	6.254
32068	Clay	019	0.891	0.715	6.087
32073	Clay	019	1.146	0.922	7.503
32656	Clay	019	1.024	0.821	6.977
34102	Collier	021	12.141	10.114	47.638
34103	Collier	021	11.316	9.417	45.170
34104	Collier	021	6.046	4.922	29.721
34105	Collier	021	7.288	5.964	33.802
34108	Collier	021	10.531	8.746	43.124
34109	Collier	021	6.765	5.524	32.195
34110	Collier	021	7.437	6.088	34.206
34112	Collier	021	7.796	6.426	34.616
34113	Collier	021	6.941	5.687	32.149
34114	Collier	021	5.534	4.498	27.823
34116	Collier	021	4.719	3.808	25.244
34117	Collier	021	4.471	3.605	24.614
34119	Collier	021	4.497	3.630	24.405
34120	Collier	021	4.470	3.603	24.674
34138	Collier	021	10.044	8.248	43.530
34139	Collier	021	8.089	6.608	36.095
34140	Collier	021	11.575	9.620	46.886
34141	Collier	021	5.267	4.248	28.763
34142	Collier	021	4.452	3.583	25.504
34145	Collier	021	14.442	12.169	52.557
32024	Columbia	023	0.935	0.752	6.383
32025	Columbia	023	0.772	0.620	5.422
32038	Columbia	023	0.956	0.770	6.464
32055	Columbia	023	0.750	0.602	5.313

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type		
			Frame Owners	Masonry Owners	Manufactured Homes
32061	Columbia	023	0.850	0.683	5.865
34266	DeSoto	027	2.960	2.372	18.111
34269	DeSoto	027	2.986	2.403	16.922
32628	Dixie	029	1.162	0.937	7.482
32648	Dixie	029	3.488	2.885	17.039
32680	Dixie	029	1.265	1.021	8.152
32202	Duval	031	1.052	0.846	6.933
32204	Duval	031	1.020	0.820	6.765
32205	Duval	031	1.013	0.814	6.790
32206	Duval	031	1.020	0.821	6.739
32207	Duval	031	1.073	0.863	7.070
32208	Duval	031	0.924	0.745	6.190
32209	Duval	031	0.992	0.798	6.605
32210	Duval	031	1.038	0.836	6.939
32211	Duval	031	1.067	0.860	6.953
32212	Duval	031	1.106	0.890	7.253
32214	Duval	031	1.117	0.899	7.317
32216	Duval	031	1.118	0.899	7.314
32217	Duval	031	1.122	0.902	7.379
32218	Duval	031	0.904	0.728	6.007
32219	Duval	031	0.830	0.668	5.639
32220	Duval	031	0.817	0.657	5.611
32221	Duval	031	0.846	0.680	5.821
32222	Duval	031	0.887	0.712	6.104
32223	Duval	031	1.170	0.942	7.648
32224	Duval	031	1.331	1.074	8.407
32225	Duval	031	1.191	0.960	7.637
32226	Duval	031	1.037	0.837	6.713
32227	Duval	031	3.090	2.534	16.465
32233	Duval	031	2.788	2.281	15.102
32234	Duval	031	0.749	0.601	5.300
32244	Duval	031	1.123	0.903	7.480
32246	Duval	031	1.074	0.866	7.009
32250	Duval	031	2.672	2.181	14.497
32254	Duval	031	1.001	0.806	6.667
32256	Duval	031	1.035	0.833	6.860

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type Frame Owners	Masonry Owners	Manufactured Homes
32257	Duval	031	1.171	0.944	7.640
32258	Duval	031	1.068	0.862	7.047
32266	Duval	031	2.931	2.400	15.624
32277	Duval	031	0.984	0.792	6.524
32501	Escambia	033	8.298	6.776	38.942
32502	Escambia	033	9.077	7.424	41.639
32503	Escambia	033	7.578	6.179	36.315
32504	Escambia	033	6.735	5.475	33.257
32505	Escambia	033	6.229	5.063	31.586
32506	Escambia	033	6.914	5.619	34.255
32507	Escambia	033	11.717	9.655	49.230
32508	Escambia	033	13.587	11.271	54.621
32509	Escambia	033	4.054	3.273	23.210
32511	Escambia	033	7.763	6.330	36.939
32512	Escambia	033	8.481	6.926	39.297
32514	Escambia	033	4.955	4.009	26.470
32526	Escambia	033	3.910	3.156	22.562
32533	Escambia	033	3.251	2.618	19.524
32534	Escambia	033	3.635	2.932	21.188
32535	Escambia	033	1.913	1.536	12.846
32568	Escambia	033	2.068	1.662	13.665
32577	Escambia	033	2.563	2.061	16.219
32110	Flagler	035	1.276	1.022	8.908
32136	Flagler	035	4.272	3.474	22.014
32137	Flagler	035	2.769	2.233	15.720
32164	Flagler	035	1.738	1.394	11.253
32320	Franklin	037	9.462	7.837	37.996
32322	Franklin	037	7.429	6.162	30.884
32323	Franklin	037	8.192	6.796	32.971
32328	Franklin	037	8.982	7.529	34.684
32324	Gadsden	039	1.135	0.912	7.710
32330	Gadsden	039	1.205	0.969	7.981
32332	Gadsden	039	1.092	0.878	7.343
32333	Gadsden	039	0.966	0.777	6.518
32343	Gadsden	039	1.131	0.910	7.403
32351	Gadsden	039	1.131	0.909	7.522

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Hurricane Model Release Date:	10/1/2020

ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type Frame Owners	Masonry Owners	Manufactured Homes
32352	Gadsden	039	1.030	0.828	6.976
32619	Gilchrist	041	1.158	0.934	7.468
32693	Gilchrist	041	1.345	1.087	8.398
33471	Glades	043	3.953	3.174	23.665
32456	Gulf	045	7.613	6.260	33.284
32465	Gulf	045	2.660	2.142	15.649
32052	Hamilton	047	0.626	0.502	4.554
32053	Hamilton	047	0.621	0.498	4.529
32096	Hamilton	047	0.698	0.560	5.032
33834	Hardee	049	2.569	2.060	16.190
33865	Hardee	049	2.661	2.134	16.376
33873	Hardee	049	2.618	2.099	16.561
33890	Hardee	049	2.591	2.075	16.472
33440	Hendry	051	5.110	4.102	29.464
33935	Hendry	051	4.040	3.252	23.347
34601	Hernando	053	1.834	1.477	11.159
34602	Hernando	053	1.858	1.496	11.511
34604	Hernando	053	2.108	1.704	12.344
34606	Hernando	053	3.162	2.572	16.697
34607	Hernando	053	4.420	3.645	19.843
34608	Hernando	053	2.360	1.911	13.428
34609	Hernando	053	2.213	1.789	12.772
34613	Hernando	053	2.157	1.741	12.550
34614	Hernando	053	2.014	1.625	11.898
34661	Hernando	053	1.685	1.353	10.832
33825	Highlands	055	2.471	1.978	16.101
33852	Highlands	055	3.469	2.782	21.309
33857	Highlands	055	4.054	3.254	24.400
33870	Highlands	055	2.531	2.026	16.539
33872	Highlands	055	2.487	1.989	16.294
33875	Highlands	055	2.610	2.088	16.972
33876	Highlands	055	3.541	2.840	21.601
33960	Highlands	055	3.281	2.628	20.407
33510	Hillsborough	057	2.331	1.879	13.979
33511	Hillsborough	057	2.448	1.975	14.466
33527	Hillsborough	057	2.195	1.763	13.614

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ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type Frame Owners	Masonry Owners	Manufactured Homes
33534	Hillsborough	057	3.553	2.890	18.871
33547	Hillsborough	057	2.399	1.926	14.703
33548	Hillsborough	057	2.451	1.984	13.943
33549	Hillsborough	057	2.390	1.933	13.794
33556	Hillsborough	057	2.523	2.046	14.157
33558	Hillsborough	057	2.541	2.061	14.240
33563	Hillsborough	057	2.229	1.789	14.040
33565	Hillsborough	057	2.196	1.766	13.733
33566	Hillsborough	057	2.208	1.772	13.955
33567	Hillsborough	057	2.169	1.740	13.768
33569	Hillsborough	057	2.645	2.134	15.366
33570	Hillsborough	057	4.089	3.326	21.505
33572	Hillsborough	057	4.053	3.308	20.810
33573	Hillsborough	057	3.057	2.466	17.316
33578	Hillsborough	057	3.072	2.490	16.964
33579	Hillsborough	057	2.727	2.198	15.818
33584	Hillsborough	057	2.233	1.798	13.586
33592	Hillsborough	057	2.249	1.813	13.578
33594	Hillsborough	057	2.251	1.809	13.798
33596	Hillsborough	057	2.369	1.904	14.322
33598	Hillsborough	057	2.843	2.288	16.407
33602	Hillsborough	057	3.573	2.915	18.465
33603	Hillsborough	057	3.050	2.478	16.499
33604	Hillsborough	057	2.483	2.009	14.266
33605	Hillsborough	057	3.138	2.549	16.782
33606	Hillsborough	057	3.992	3.277	18.820
33607	Hillsborough	057	4.190	3.426	20.465
33609	Hillsborough	057	4.645	3.811	22.145
33610	Hillsborough	057	2.469	1.995	14.249
33611	Hillsborough	057	5.632	4.647	25.590
33612	Hillsborough	057	2.351	1.898	13.714
33613	Hillsborough	057	2.353	1.901	13.698
33614	Hillsborough	057	3.113	2.528	16.501
33615	Hillsborough	057	4.136	3.418	19.584
33616	Hillsborough	057	6.238	5.164	27.702
33617	Hillsborough	057	2.310	1.866	13.577

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			Hurricane Lost Cost per Policy Type		
ZIP Code	**County Name**	**FIPS Code**	**Frame Owners**	**Masonry Owners**	**Manufactured Homes**
33618	Hillsborough	057	2.437	1.970	13.936
33619	Hillsborough	057	2.955	2.397	16.262
33620	Hillsborough	057	2.323	1.877	13.616
33621	Hillsborough	057	5.904	4.886	25.758
33624	Hillsborough	057	2.510	2.032	14.178
33625	Hillsborough	057	2.732	2.217	14.985
33626	Hillsborough	057	3.249	2.648	17.044
33629	Hillsborough	057	4.954	4.072	23.341
33634	Hillsborough	057	4.121	3.396	19.958
33635	Hillsborough	057	3.847	3.165	18.918
33637	Hillsborough	057	2.271	1.835	13.470
33647	Hillsborough	057	2.307	1.863	13.744
32425	Holmes	059	1.485	1.193	9.790
32464	Holmes	059	1.483	1.192	9.845
00087	Indian River	061	4.039	3.246	23.843
32948	Indian River	061	4.409	3.550	25.386
32958	Indian River	061	8.405	6.870	38.397
32960	Indian River	061	9.951	8.158	44.471
32962	Indian River	061	9.359	7.660	42.993
32963	Indian River	061	14.303	11.958	55.598
32966	Indian River	061	5.254	4.241	28.860
32967	Indian River	061	6.671	5.414	33.518
32968	Indian River	061	6.400	5.184	33.350
32420	Jackson	063	1.729	1.390	11.086
32423	Jackson	063	1.086	0.872	7.502
32426	Jackson	063	1.219	0.979	8.321
32431	Jackson	063	1.423	1.143	9.495
32440	Jackson	063	1.344	1.079	9.003
32442	Jackson	063	1.293	1.039	8.661
32443	Jackson	063	1.191	0.957	8.117
32445	Jackson	063	1.085	0.872	7.514
32446	Jackson	063	1.245	1.000	8.423
32448	Jackson	063	1.373	1.103	9.134
32460	Jackson	063	1.181	0.949	8.003
32336	Jefferson	065	0.891	0.716	6.162
32344	Jefferson	065	0.810	0.650	5.697

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			Hurricane Lost Cost per Policy Type		
ZIP Code	**County Name**	**FIPS Code**	**Frame Owners**	**Masonry Owners**	**Manufactured Homes**
32013	Lafayette	067	0.966	0.777	6.372
32066	Lafayette	067	1.027	0.827	6.670
32102	Lake	069	1.427	1.142	9.734
32159	Lake	069	1.717	1.374	11.391
32702	Lake	069	1.375	1.100	9.564
32726	Lake	069	2.098	1.681	13.653
32735	Lake	069	1.984	1.590	12.980
32736	Lake	069	1.597	1.278	10.885
32757	Lake	069	2.065	1.655	13.500
32767	Lake	069	1.362	1.089	9.507
32776	Lake	069	1.620	1.296	11.032
32778	Lake	069	2.294	1.840	14.692
32784	Lake	069	1.686	1.350	11.324
34705	Lake	069	2.499	2.005	15.751
34711	Lake	069	2.305	1.847	14.861
34714	Lake	069	1.931	1.546	12.909
34715	Lake	069	2.472	1.982	15.742
34731	Lake	069	1.942	1.556	12.622
34736	Lake	069	2.002	1.604	13.070
34737	Lake	069	2.208	1.770	14.269
34748	Lake	069	2.106	1.688	13.640
34753	Lake	069	1.921	1.539	12.583
34756	Lake	069	2.585	2.072	16.382
34762	Lake	069	2.096	1.680	13.560
34788	Lake	069	2.300	1.843	14.700
34797	Lake	069	2.080	1.666	13.574
33901	Lee	071	3.532	2.846	20.063
33903	Lee	071	3.406	2.742	18.986
33904	Lee	071	4.041	3.271	21.019
33905	Lee	071	3.510	2.821	20.333
33907	Lee	071	3.746	3.027	20.682
33908	Lee	071	5.959	4.878	27.718
33909	Lee	071	3.447	2.772	19.738
33912	Lee	071	3.880	3.132	21.487
33913	Lee	071	3.859	3.109	21.667
33914	Lee	071	4.813	3.916	23.541

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ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type		
			Frame Owners	Masonry Owners	Manufactured Homes
33916	Lee	071	3.533	2.845	20.120
33917	Lee	071	3.339	2.684	19.430
33919	Lee	071	4.032	3.265	21.269
33920	Lee	071	3.692	2.966	21.572
33921	Lee	071	10.820	9.026	43.345
33922	Lee	071	7.987	6.541	36.575
33924	Lee	071	11.631	9.721	45.232
33928	Lee	071	4.710	3.809	24.953
33931	Lee	071	9.418	7.877	36.186
33936	Lee	071	4.061	3.272	22.984
33956	Lee	071	7.395	6.082	33.142
33957	Lee	071	12.853	10.839	46.718
33965	Lee	071	4.175	3.370	23.023
33966	Lee	071	3.733	3.008	20.973
33967	Lee	071	4.535	3.667	24.094
33971	Lee	071	3.675	2.958	21.115
33972	Lee	071	3.988	3.214	22.711
33973	Lee	071	3.732	3.004	21.265
33974	Lee	071	4.221	3.402	23.722
33976	Lee	071	3.887	3.132	22.002
33990	Lee	071	3.614	2.912	20.040
33991	Lee	071	4.141	3.343	22.183
33993	Lee	071	4.018	3.238	21.983
34134	Lee	071	8.270	6.856	35.110
34135	Lee	071	5.236	4.252	26.700
32301	Leon	073	1.081	0.869	7.113
32303	Leon	073	1.089	0.876	7.163
32304	Leon	073	1.096	0.882	7.187
32305	Leon	073	1.151	0.926	7.415
32306	Leon	073	1.087	0.874	7.140
32307	Leon	073	1.092	0.878	7.167
32308	Leon	073	1.040	0.836	6.902
32309	Leon	073	0.943	0.758	6.369
32310	Leon	073	1.158	0.932	7.508
32311	Leon	073	1.061	0.853	6.961
32312	Leon	073	0.961	0.772	6.519

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ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type		
			Frame Owners	Masonry Owners	Manufactured Homes
32317	Leon	073	0.991	0.797	6.573
32399	Leon	073	1.082	0.869	7.116
32621	Levy	075	1.334	1.070	8.775
32625	Levy	075	4.886	4.039	22.371
32626	Levy	075	1.376	1.112	8.752
32668	Levy	075	1.567	1.256	10.252
32696	Levy	075	1.367	1.095	9.116
34449	Levy	075	1.680	1.349	10.496
34498	Levy	075	3.447	2.825	17.188
32321	Liberty	077	1.621	1.305	10.231
32334	Liberty	077	1.548	1.246	9.768
32059	Madison	079	0.720	0.578	5.086
32331	Madison	079	0.775	0.622	5.388
32340	Madison	079	0.740	0.594	5.204
32350	Madison	079	0.653	0.524	4.711
34201	Manatee	081	2.909	2.343	16.378
34202	Manatee	081	2.817	2.266	16.246
34203	Manatee	081	3.383	2.744	18.103
34205	Manatee	081	4.742	3.877	23.134
34207	Manatee	081	5.303	4.350	24.524
34208	Manatee	081	3.254	2.632	17.721
34209	Manatee	081	6.674	5.492	29.752
34210	Manatee	081	6.958	5.752	29.932
34211	Manatee	081	2.856	2.299	16.396
34212	Manatee	081	2.897	2.337	16.479
34215	Manatee	081	9.589	8.066	37.051
34216	Manatee	081	10.948	9.195	41.909
34217	Manatee	081	10.455	8.763	40.789
34219	Manatee	081	3.002	2.421	16.945
34221	Manatee	081	4.260	3.468	21.745
34222	Manatee	081	3.198	2.585	17.647
34243	Manatee	081	3.773	3.065	19.409
34251	Manatee	081	2.914	2.346	17.193
00045	Marion	083	1.143	0.914	8.126
32113	Marion	083	1.239	0.993	8.312
32134	Marion	083	1.001	0.801	7.081

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32179	Marion	083	1.307	1.046	8.996
32195	Marion	083	1.543	1.235	10.408
32617	Marion	083	1.221	0.980	8.209
32667	Marion	083	1.120	0.897	7.644
32686	Marion	083	1.294	1.037	8.598
34420	Marion	083	1.526	1.225	10.043
34431	Marion	083	1.597	1.281	10.078
34432	Marion	083	1.577	1.267	9.950
34470	Marion	083	1.320	1.060	8.726
34471	Marion	083	1.410	1.134	9.216
34472	Marion	083	1.336	1.073	8.901
34473	Marion	083	1.579	1.268	10.071
34474	Marion	083	1.490	1.198	9.603
34475	Marion	083	1.418	1.140	9.267
34476	Marion	083	1.531	1.231	9.775
34478	Marion	083	1.423	1.144	9.288
34479	Marion	083	1.309	1.053	8.662
34480	Marion	083	1.401	1.125	9.210
34481	Marion	083	1.555	1.249	9.909
34482	Marion	083	1.411	1.133	9.229
34488	Marion	083	1.111	0.889	7.766
34491	Marion	083	1.588	1.275	10.489
33455	Martin	085	14.621	12.077	59.022
34956	Martin	085	5.820	4.688	32.783
34957	Martin	085	14.249	11.791	57.512
34990	Martin	085	6.496	5.249	34.595
34994	Martin	085	9.192	7.505	43.204
34996	Martin	085	13.820	11.439	56.324
34997	Martin	085	9.408	7.673	44.283
00043	Miami-Dade	086	6.823	5.505	35.899
33010	Miami-Dade	086	6.690	5.392	35.563
33012	Miami-Dade	086	6.528	5.261	35.062
33013	Miami-Dade	086	6.604	5.322	35.267
33014	Miami-Dade	086	6.511	5.247	35.040
33015	Miami-Dade	086	6.525	5.259	35.122
33016	Miami-Dade	086	6.600	5.321	35.403

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ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type		
			Frame Owners	Masonry Owners	Manufactured Homes
33018	Miami-Dade	086	6.595	5.319	35.346
33030	Miami-Dade	086	8.330	6.762	40.190
33031	Miami-Dade	086	8.130	6.586	39.881
33032	Miami-Dade	086	10.304	8.443	45.659
33033	Miami-Dade	086	8.761	7.130	41.335
33034	Miami-Dade	086	8.253	6.710	39.232
33035	Miami-Dade	086	8.537	6.944	40.293
33039	Miami-Dade	086	11.110	9.151	47.047
33054	Miami-Dade	086	6.764	5.454	35.832
33055	Miami-Dade	086	6.452	5.197	34.762
33056	Miami-Dade	086	6.593	5.313	35.265
33109	Miami-Dade	086	24.616	20.667	83.386
33122	Miami-Dade	086	6.547	5.274	35.117
33125	Miami-Dade	086	10.682	8.705	48.430
33126	Miami-Dade	086	7.511	6.066	38.486
33127	Miami-Dade	086	11.120	9.080	49.583
33128	Miami-Dade	086	13.518	11.107	56.307
33129	Miami-Dade	086	15.744	12.993	62.175
33130	Miami-Dade	086	14.788	12.174	59.746
33131	Miami-Dade	086	16.494	13.725	63.235
33132	Miami-Dade	086	15.176	12.513	60.615
33133	Miami-Dade	086	13.642	11.199	56.414
33134	Miami-Dade	086	9.866	8.024	45.905
33135	Miami-Dade	086	11.848	9.681	51.805
33136	Miami-Dade	086	13.233	10.855	55.603
33137	Miami-Dade	086	13.201	10.844	55.270
33138	Miami-Dade	086	12.028	9.864	51.724
33139	Miami-Dade	086	22.650	19.102	77.817
33140	Miami-Dade	086	23.134	19.452	79.168
33141	Miami-Dade	086	20.384	17.123	71.868
33142	Miami-Dade	086	9.175	7.449	43.796
33143	Miami-Dade	086	11.864	9.732	50.808
33144	Miami-Dade	086	7.463	6.027	38.307
33145	Miami-Dade	086	12.520	10.248	53.634
33146	Miami-Dade	086	12.613	10.344	53.244
33147	Miami-Dade	086	7.796	6.309	39.246

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Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type		
			Frame Owners	Masonry Owners	Manufactured Homes
33149	Miami-Dade	086	26.707	22.577	88.719
33150	Miami-Dade	086	9.549	7.772	44.661
33154	Miami-Dade	086	20.840	17.514	73.038
33155	Miami-Dade	086	8.500	6.888	41.587
33156	Miami-Dade	086	13.566	11.234	54.272
33157	Miami-Dade	086	13.190	10.847	54.031
33158	Miami-Dade	086	15.397	12.840	58.682
33160	Miami-Dade	086	19.843	16.646	70.747
33161	Miami-Dade	086	11.794	9.668	51.095
33162	Miami-Dade	086	12.447	10.232	52.771
33165	Miami-Dade	086	6.890	5.557	36.294
33166	Miami-Dade	086	6.614	5.329	35.347
33167	Miami-Dade	086	7.684	6.215	38.942
33168	Miami-Dade	086	8.854	7.186	42.666
33169	Miami-Dade	086	7.809	6.318	39.444
33170	Miami-Dade	086	9.895	8.076	44.963
33172	Miami-Dade	086	6.593	5.313	35.229
33173	Miami-Dade	086	7.432	6.006	37.856
33174	Miami-Dade	086	6.666	5.373	35.474
33175	Miami-Dade	086	6.972	5.626	36.526
33176	Miami-Dade	086	8.927	7.245	42.791
33177	Miami-Dade	086	8.354	6.765	41.137
33178	Miami-Dade	086	6.519	5.252	35.045
33179	Miami-Dade	086	11.302	9.258	49.734
33180	Miami-Dade	086	19.097	15.964	69.019
33181	Miami-Dade	086	15.774	13.088	61.220
33182	Miami-Dade	086	6.688	5.390	35.617
33183	Miami-Dade	086	7.182	5.803	37.157
33184	Miami-Dade	086	6.820	5.500	36.022
33185	Miami-Dade	086	7.124	5.752	37.050
33186	Miami-Dade	086	7.490	6.056	38.032
33187	Miami-Dade	086	7.627	6.160	38.779
33189	Miami-Dade	086	15.338	12.816	57.968
33190	Miami-Dade	086	15.532	13.029	57.633
33193	Miami-Dade	086	7.254	5.860	37.508
33194	Miami-Dade	086	7.013	5.658	36.870

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			Hurricane Lost Cost per Policy Type		
ZIP Code	**County Name**	**FIPS Code**	**Frame Owners**	**Masonry Owners**	**Manufactured Homes**
33196	Miami-Dade	086	7.388	5.973	37.821
33199	Miami-Dade	086	6.718	5.417	35.606
00097	Monroe	087	6.168	4.976	32.748
00098	Monroe	087	9.788	8.036	42.472
33036	Monroe	087	26.722	22.779	84.198
33037	Monroe	087	24.232	20.665	77.896
33040	Monroe	087	29.371	25.119	88.352
33042	Monroe	087	23.447	19.955	73.003
33043	Monroe	087	24.400	20.789	75.772
33050	Monroe	087	28.105	24.023	85.214
33051	Monroe	087	27.833	23.756	84.920
33070	Monroe	087	26.694	22.811	83.579
32009	Nassau	089	0.689	0.554	4.848
32011	Nassau	089	0.714	0.576	4.933
32034	Nassau	089	2.022	1.654	11.436
32046	Nassau	089	0.611	0.490	4.412
32097	Nassau	089	0.906	0.734	5.899
32531	Okaloosa	091	1.922	1.544	12.564
32536	Okaloosa	091	2.191	1.761	13.810
32539	Okaloosa	091	2.172	1.746	13.697
32541	Okaloosa	091	13.063	10.821	51.556
32542	Okaloosa	091	6.147	5.004	29.987
32544	Okaloosa	091	10.840	8.949	45.624
32547	Okaloosa	091	7.851	6.424	36.067
32548	Okaloosa	091	11.808	9.755	47.847
32564	Okaloosa	091	2.272	1.827	14.347
32567	Okaloosa	091	1.544	1.240	10.379
32569	Okaloosa	091	11.263	9.304	46.916
32578	Okaloosa	091	4.806	3.910	24.277
32579	Okaloosa	091	8.336	6.829	37.449
32580	Okaloosa	091	4.661	3.775	24.537
34972	Okeechobee	093	4.557	3.664	26.547
34974	Okeechobee	093	6.778	5.472	35.864
32703	Orange	095	1.850	1.480	12.433
32709	Orange	095	2.172	1.741	13.934
32712	Orange	095	1.997	1.598	13.115

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			Hurricane Lost Cost per Policy Type		
ZIP Code	County Name	FIPS Code	Frame Owners	Masonry Owners	Manufactured Homes
32751	Orange	095	1.683	1.347	11.494
32789	Orange	095	1.698	1.359	11.592
32792	Orange	095	1.735	1.388	11.777
32798	Orange	095	2.394	1.920	15.075
32801	Orange	095	1.722	1.378	11.752
32803	Orange	095	1.724	1.380	11.757
32804	Orange	095	1.706	1.365	11.658
32805	Orange	095	1.733	1.387	11.814
32806	Orange	095	1.726	1.380	11.764
32807	Orange	095	1.763	1.411	11.951
32808	Orange	095	1.749	1.399	11.901
32809	Orange	095	1.778	1.423	12.071
32810	Orange	095	1.693	1.354	11.582
32811	Orange	095	1.775	1.421	12.044
32812	Orange	095	1.762	1.410	11.974
32814	Orange	095	1.733	1.386	11.789
32816	Orange	095	1.869	1.497	12.467
32817	Orange	095	1.796	1.438	12.105
32818	Orange	095	1.857	1.486	12.516
32819	Orange	095	1.767	1.414	12.001
32820	Orange	095	1.936	1.550	12.802
32821	Orange	095	1.765	1.413	12.011
32822	Orange	095	1.814	1.452	12.261
32824	Orange	095	2.081	1.666	13.793
32825	Orange	095	1.823	1.459	12.277
32826	Orange	095	1.878	1.504	12.522
32827	Orange	095	2.118	1.696	13.922
32828	Orange	095	1.933	1.548	12.843
32829	Orange	095	1.896	1.518	12.726
32830	Orange	095	1.847	1.478	12.462
32831	Orange	095	2.087	1.671	13.713
32832	Orange	095	2.132	1.707	13.993
32833	Orange	095	2.091	1.675	13.650
32835	Orange	095	1.790	1.433	12.127
32836	Orange	095	1.759	1.408	11.980
32837	Orange	095	1.861	1.490	12.562

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			Hurricane Lost Cost per Policy Type		
ZIP Code	**County Name**	**FIPS Code**	**Frame Owners**	**Masonry Owners**	**Manufactured Homes**
32839	Orange	095	1.767	1.414	11.995
34734	Orange	095	2.091	1.675	13.764
34760	Orange	095	2.455	1.968	15.617
34761	Orange	095	2.294	1.838	14.802
34786	Orange	095	1.910	1.529	12.804
34787	Orange	095	2.347	1.880	15.105
34739	Osceola	097	3.215	2.576	19.921
34741	Osceola	097	2.060	1.649	13.676
34743	Osceola	097	2.369	1.897	15.353
34744	Osceola	097	2.500	2.003	16.007
34746	Osceola	097	2.254	1.804	14.804
34747	Osceola	097	1.827	1.462	12.376
34758	Osceola	097	2.329	1.864	15.306
34769	Osceola	097	2.808	2.253	17.606
34771	Osceola	097	2.509	2.010	16.098
34772	Osceola	097	2.948	2.365	18.434
34773	Osceola	097	2.813	2.254	17.662
00053	Palm Beach	099	6.561	5.283	36.269
33401	Palm Beach	099	14.890	12.282	60.220
33403	Palm Beach	099	14.702	12.126	59.525
33404	Palm Beach	099	15.358	12.680	61.314
33405	Palm Beach	099	16.763	13.887	64.964
33406	Palm Beach	099	10.837	8.854	49.209
33407	Palm Beach	099	13.029	10.693	55.292
33408	Palm Beach	099	17.329	14.386	66.196
33409	Palm Beach	099	9.830	8.006	46.325
33410	Palm Beach	099	12.985	10.680	54.861
33411	Palm Beach	099	5.884	4.740	32.967
33412	Palm Beach	099	5.861	4.722	32.801
33413	Palm Beach	099	6.273	5.058	34.323
33414	Palm Beach	099	5.945	4.788	33.340
33415	Palm Beach	099	7.240	5.852	37.879
33417	Palm Beach	099	7.275	5.884	37.966
33418	Palm Beach	099	7.556	6.124	38.737
33426	Palm Beach	099	14.846	12.267	59.706
33428	Palm Beach	099	6.340	5.108	34.683

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ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type		
			Frame Owners	Masonry Owners	Manufactured Homes
33430	Palm Beach	099	6.634	5.338	37.070
33431	Palm Beach	099	16.092	13.349	62.514
33432	Palm Beach	099	18.688	15.591	68.977
33433	Palm Beach	099	7.780	6.294	39.851
33434	Palm Beach	099	6.801	5.488	36.474
33435	Palm Beach	099	18.120	15.092	67.856
33436	Palm Beach	099	10.975	8.964	49.752
33437	Palm Beach	099	7.126	5.751	37.929
33438	Palm Beach	099	11.474	9.348	53.970
33444	Palm Beach	099	17.328	14.415	65.605
33445	Palm Beach	099	12.872	10.574	54.626
33446	Palm Beach	099	6.597	5.316	35.882
33449	Palm Beach	099	5.915	4.761	33.178
33458	Palm Beach	099	10.904	8.923	48.909
33460	Palm Beach	099	17.080	14.160	65.586
33461	Palm Beach	099	11.147	9.106	50.102
33462	Palm Beach	099	15.155	12.526	60.528
33463	Palm Beach	099	7.287	5.881	38.325
33467	Palm Beach	099	6.048	4.866	33.801
33469	Palm Beach	099	15.764	13.055	62.100
33470	Palm Beach	099	6.036	4.862	33.800
33472	Palm Beach	099	6.344	5.111	34.976
33473	Palm Beach	099	6.230	5.017	34.543
33476	Palm Beach	099	11.868	9.669	55.458
33477	Palm Beach	099	17.664	14.681	67.062
33478	Palm Beach	099	5.910	4.762	32.785
33480	Palm Beach	099	18.831	15.678	70.329
33483	Palm Beach	099	19.155	16.000	70.169
33484	Palm Beach	099	8.709	7.058	43.032
33486	Palm Beach	099	13.790	11.365	56.905
33487	Palm Beach	099	17.790	14.820	66.446
33493	Palm Beach	099	6.687	5.383	37.181
33496	Palm Beach	099	6.904	5.571	36.892
33498	Palm Beach	099	6.402	5.157	35.042
33523	Pasco	101	1.945	1.565	12.119
33525	Pasco	101	2.202	1.775	13.387

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			Frame Owners	Masonry Owners	Manufactured Homes
33540	Pasco	101	2.183	1.757	13.524
33541	Pasco	101	2.264	1.824	13.859
33542	Pasco	101	2.242	1.806	13.824
33543	Pasco	101	2.262	1.824	13.628
33544	Pasco	101	2.376	1.919	13.980
33545	Pasco	101	2.281	1.840	13.675
33559	Pasco	101	2.360	1.907	13.766
33576	Pasco	101	2.298	1.855	13.646
34610	Pasco	101	2.322	1.878	13.269
34637	Pasco	101	2.441	1.972	13.885
34638	Pasco	101	2.512	2.035	14.104
34639	Pasco	101	2.418	1.954	13.990
34652	Pasco	101	5.335	4.428	23.574
34653	Pasco	101	3.991	3.263	19.628
34654	Pasco	101	2.720	2.204	14.913
34655	Pasco	101	2.802	2.274	15.266
34667	Pasco	101	4.987	4.093	22.919
34668	Pasco	101	5.003	4.124	22.655
34669	Pasco	101	2.775	2.252	15.181
34690	Pasco	101	4.550	3.732	21.604
34691	Pasco	101	6.105	5.073	26.639
33701	Pinellas	103	7.340	6.071	30.886
33702	Pinellas	103	4.844	3.981	22.940
33703	Pinellas	103	5.910	4.892	26.193
33704	Pinellas	103	6.487	5.350	28.192
33705	Pinellas	103	8.126	6.733	33.738
33706	Pinellas	103	8.594	7.200	33.901
33707	Pinellas	103	7.509	6.232	31.280
33708	Pinellas	103	7.891	6.621	30.627
33709	Pinellas	103	4.688	3.841	22.284
33710	Pinellas	103	5.760	4.749	25.788
33711	Pinellas	103	7.586	6.328	30.835
33712	Pinellas	103	8.391	6.960	34.360
33713	Pinellas	103	5.622	4.617	25.575
33714	Pinellas	103	4.594	3.750	22.231
33715	Pinellas	103	9.760	8.202	37.140

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			Frame Owners	Masonry Owners	Manufactured Homes
33716	Pinellas	103	4.333	3.551	21.335
33755	Pinellas	103	5.862	4.850	26.102
33756	Pinellas	103	5.840	4.824	25.873
33759	Pinellas	103	4.158	3.397	20.418
33760	Pinellas	103	3.766	3.065	19.284
33761	Pinellas	103	4.356	3.567	21.123
33762	Pinellas	103	3.912	3.196	19.705
33763	Pinellas	103	4.810	3.946	22.733
33764	Pinellas	103	4.171	3.417	20.537
33765	Pinellas	103	4.622	3.788	22.085
33767	Pinellas	103	7.376	6.184	29.648
33770	Pinellas	103	6.368	5.270	27.539
33771	Pinellas	103	4.207	3.442	20.779
33772	Pinellas	103	7.409	6.147	30.845
33773	Pinellas	103	4.138	3.376	20.674
33774	Pinellas	103	8.356	6.954	33.854
33776	Pinellas	103	9.175	7.646	36.256
33777	Pinellas	103	4.607	3.778	22.122
33778	Pinellas	103	6.334	5.233	27.599
33781	Pinellas	103	3.719	3.029	19.105
33782	Pinellas	103	3.578	2.911	18.651
33785	Pinellas	103	8.886	7.431	35.307
33786	Pinellas	103	8.130	6.798	32.942
34677	Pinellas	103	3.476	2.844	17.643
34681	Pinellas	103	6.242	5.198	26.795
34683	Pinellas	103	5.489	4.529	24.418
34684	Pinellas	103	4.174	3.416	20.308
34685	Pinellas	103	3.138	2.558	16.444
34688	Pinellas	103	3.062	2.490	16.295
34689	Pinellas	103	5.629	4.693	23.814
34695	Pinellas	103	4.023	3.289	19.815
34698	Pinellas	103	5.909	4.883	26.051
33801	Polk	105	2.006	1.606	13.211
33803	Polk	105	2.046	1.639	13.306
33805	Polk	105	1.955	1.567	12.850
33809	Polk	105	2.009	1.611	13.138

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ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type		
			Frame Owners	Masonry Owners	Manufactured Homes
33810	Polk	105	2.009	1.612	13.032
33811	Polk	105	2.147	1.721	13.694
33812	Polk	105	2.150	1.722	13.958
33813	Polk	105	2.186	1.752	14.051
33815	Polk	105	2.003	1.606	13.011
33823	Polk	105	2.089	1.673	13.811
33827	Polk	105	2.463	1.973	15.989
33830	Polk	105	2.360	1.890	15.226
33837	Polk	105	1.934	1.548	12.988
33838	Polk	105	2.227	1.781	14.858
33839	Polk	105	2.220	1.777	14.579
33841	Polk	105	2.517	2.017	16.108
33843	Polk	105	2.410	1.931	15.692
33844	Polk	105	2.135	1.708	14.220
33849	Polk	105	2.004	1.607	12.757
33850	Polk	105	2.085	1.670	13.848
33853	Polk	105	2.451	1.962	16.026
33854	Polk	105	2.660	2.131	17.125
33855	Polk	105	2.742	2.198	17.499
33859	Polk	105	2.429	1.945	15.896
33860	Polk	105	2.331	1.869	14.653
33868	Polk	105	2.057	1.650	13.501
33880	Polk	105	2.251	1.803	14.769
33881	Polk	105	2.149	1.721	14.258
33884	Polk	105	2.263	1.810	14.988
33896	Polk	105	1.863	1.492	12.579
33897	Polk	105	1.847	1.479	12.432
33898	Polk	105	2.416	1.934	15.879
34759	Polk	105	2.261	1.809	14.978
32112	Putnam	107	1.491	1.194	10.099
32131	Putnam	107	1.166	0.934	7.963
32139	Putnam	107	1.587	1.271	10.560
32140	Putnam	107	0.995	0.798	6.856
32148	Putnam	107	1.016	0.814	7.068
32177	Putnam	107	1.098	0.879	7.636
32181	Putnam	107	1.272	1.018	8.802

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ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type		
			Frame Owners	Masonry Owners	Manufactured Homes
32187	Putnam	107	1.199	0.960	8.243
32189	Putnam	107	1.145	0.916	7.977
32193	Putnam	107	1.099	0.879	7.748
32640	Putnam	107	1.061	0.852	7.276
32666	Putnam	107	1.051	0.842	7.207
32561	Santa Rosa	113	15.688	13.009	61.556
32563	Santa Rosa	113	12.965	10.685	53.853
32565	Santa Rosa	113	2.030	1.631	13.367
32566	Santa Rosa	113	10.143	8.346	44.137
32570	Santa Rosa	113	2.780	2.235	17.312
32571	Santa Rosa	113	3.161	2.542	19.212
32583	Santa Rosa	113	3.235	2.602	19.495
34223	Sarasota	115	7.353	6.084	32.074
34228	Sarasota	115	8.925	7.521	34.200
34229	Sarasota	115	7.281	6.002	31.375
34231	Sarasota	115	7.016	5.799	30.234
34232	Sarasota	115	3.458	2.807	18.545
34233	Sarasota	115	4.142	3.367	21.106
34234	Sarasota	115	5.015	4.114	23.482
34235	Sarasota	115	3.355	2.718	17.999
34236	Sarasota	115	6.269	5.212	26.963
34237	Sarasota	115	4.596	3.760	22.409
34238	Sarasota	115	5.314	4.356	25.247
34239	Sarasota	115	5.692	4.683	26.177
34240	Sarasota	115	2.869	2.313	16.438
34241	Sarasota	115	2.925	2.357	16.691
34242	Sarasota	115	8.668	7.265	34.523
34275	Sarasota	115	6.195	5.083	28.214
34285	Sarasota	115	7.189	5.928	31.339
34286	Sarasota	115	2.781	2.238	16.327
34287	Sarasota	115	2.843	2.296	16.260
34288	Sarasota	115	2.849	2.289	16.810
34289	Sarasota	115	2.757	2.213	16.466
34291	Sarasota	115	2.742	2.210	16.049
34292	Sarasota	115	3.981	3.232	20.884
34293	Sarasota	115	5.766	4.715	27.001

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type		
			Frame Owners	Masonry Owners	Manufactured Homes
32701	Seminole	117	1.670	1.336	11.413
32707	Seminole	117	1.758	1.407	11.864
32708	Seminole	117	1.794	1.436	12.026
32714	Seminole	117	1.647	1.318	11.300
32730	Seminole	117	1.713	1.371	11.639
32732	Seminole	117	1.969	1.578	12.892
32746	Seminole	117	1.720	1.377	11.581
32750	Seminole	117	1.690	1.353	11.485
32765	Seminole	117	1.879	1.505	12.487
32766	Seminole	117	1.972	1.580	12.935
32771	Seminole	117	1.744	1.396	11.675
32773	Seminole	117	1.887	1.511	12.498
32779	Seminole	117	1.609	1.287	11.035
32033	St. Johns	109	1.250	1.009	8.314
32080	St. Johns	109	3.848	3.130	20.086
32081	St. Johns	109	1.474	1.192	9.323
32082	St. Johns	109	2.913	2.383	15.635
32084	St. Johns	109	2.351	1.904	13.633
32086	St. Johns	109	2.278	1.844	13.423
32092	St. Johns	109	1.155	0.933	7.664
32095	St. Johns	109	1.990	1.611	12.000
32145	St. Johns	109	1.164	0.932	8.062
32259	St. Johns	109	1.209	0.976	7.881
34945	St. Lucie	111	5.661	4.572	30.766
34946	St. Lucie	111	10.126	8.289	45.786
34947	St. Lucie	111	8.102	6.596	39.652
34949	St. Lucie	111	15.482	12.884	60.738
34950	St. Lucie	111	10.602	8.688	47.306
34951	St. Lucie	111	7.165	5.821	36.103
34952	St. Lucie	111	9.371	7.660	43.658
34953	St. Lucie	111	5.548	4.472	30.933
34981	St. Lucie	111	7.479	6.078	37.543
34982	St. Lucie	111	10.054	8.236	45.592
34983	St. Lucie	111	6.460	5.236	33.948
34984	St. Lucie	111	5.973	4.830	32.347
34986	St. Lucie	111	5.585	4.508	30.771

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type		
			Frame Owners	Masonry Owners	Manufactured Homes
34987	St. Lucie	111	5.593	4.508	31.186
34988	St. Lucie	111	5.387	4.341	30.419
32162	Sumter	119	1.647	1.319	10.886
32163	Sumter	119	1.642	1.315	10.914
33513	Sumter	119	1.860	1.496	11.692
33514	Sumter	119	1.906	1.527	12.274
33538	Sumter	119	1.777	1.427	11.289
33585	Sumter	119	1.887	1.517	11.990
33597	Sumter	119	1.697	1.362	10.966
34484	Sumter	119	1.621	1.300	10.641
34785	Sumter	119	1.714	1.373	11.220
32008	Suwannee	121	1.052	0.847	6.950
32060	Suwannee	121	0.844	0.677	5.880
32062	Suwannee	121	0.944	0.758	6.407
32064	Suwannee	121	0.822	0.660	5.755
32071	Suwannee	121	1.002	0.806	6.723
32094	Suwannee	121	0.860	0.691	5.957
32347	Taylor	123	1.036	0.833	6.888
32348	Taylor	123	1.182	0.952	7.617
32356	Taylor	123	1.205	0.971	7.654
32359	Taylor	123	2.046	1.664	11.444
32054	Union	125	0.868	0.696	6.029
32083	Union	125	0.797	0.640	5.557
32114	Volusia	127	3.326	2.684	18.837
32117	Volusia	127	3.317	2.677	18.731
32118	Volusia	127	4.992	4.053	25.511
32119	Volusia	127	3.252	2.624	18.484
32124	Volusia	127	1.456	1.166	10.026
32127	Volusia	127	3.687	2.990	19.895
32128	Volusia	127	1.816	1.456	11.895
32129	Volusia	127	2.810	2.261	16.547
32130	Volusia	127	1.368	1.095	9.685
32132	Volusia	127	3.786	3.067	20.234
32141	Volusia	127	3.870	3.136	20.736
32168	Volusia	127	2.395	1.927	14.580
32169	Volusia	127	5.594	4.576	27.344

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

ZIP Code	County Name	FIPS Code	Hurricane Lost Cost per Policy Type Frame Owners	Masonry Owners	Manufactured Homes
32174	Volusia	127	2.556	2.056	15.346
32176	Volusia	127	4.773	3.878	24.353
32180	Volusia	127	1.408	1.126	9.911
32190	Volusia	127	1.698	1.360	11.540
32713	Volusia	127	1.643	1.315	11.337
32720	Volusia	127	1.424	1.139	10.015
32724	Volusia	127	1.431	1.145	10.042
32725	Volusia	127	1.726	1.382	11.794
32738	Volusia	127	1.682	1.347	11.524
32744	Volusia	127	1.528	1.223	10.608
32759	Volusia	127	4.348	3.530	22.850
32763	Volusia	127	1.571	1.257	10.909
32764	Volusia	127	1.804	1.446	12.191
32327	Wakulla	129	1.473	1.191	9.044
32346	Wakulla	129	5.050	4.175	20.689
32355	Wakulla	129	2.238	1.821	11.990
32358	Wakulla	129	1.836	1.479	11.095
32433	Walton	131	1.882	1.513	12.123
32435	Walton	131	2.095	1.684	13.133
32439	Walton	131	3.891	3.139	21.621
32455	Walton	131	2.104	1.693	13.144
32459	Walton	131	10.058	8.274	43.005
32461	Walton	131	10.866	9.000	43.916
32550	Walton	131	11.473	9.531	46.510
32427	Washington	133	1.813	1.457	11.466
32428	Washington	133	1.911	1.537	11.908
32437	Washington	133	2.711	2.186	15.725
32462	Washington	133	2.251	1.813	13.529

Form A-2: Base Hurricane Storm Set Statewide Hurricane Losses

Standard A-6: Hurricane Loss Output and Logical Relationships to Risk

A. ***Provide the total insured hurricane loss and the dollar contribution to the average annual hurricane loss assuming zero deductible policies for individual historical hurricanes using the Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named "hlpm2017c.zip." The list of hurricanes in this form shall include all Florida and by-passing hurricanes in the modeling organization Base Hurricane Storm Set, as defined in Standard M-1, Base Hurricane Storm Set.***

The table below contains the minimum number of hurricanes from HURDAT2 to be included in the Base Hurricane Storm Set, based on the 119-year period 1900-2018. 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 land in 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. Each hurricane has been assigned an ID number. As defined in Standard M-1, Base Hurricane Storm Set, the Base Hurricane Storm Set for the modeling organization may exclude hurricanes that had zero modeled impact, or it may include additional hurricanes when there is clear justification for the additions. For hurricanes in the table below resulting in zero hurricane loss, the table entry shall be left blank. Additional hurricanes included in the hurricane model Base Hurricane Storm Set shall be added to the table below in order of year and assigned an intermediate ID number as the hurricane falls within the bounding ID numbers.

Note: Total dollar contributions should agree with the total average annual zero deductible statewide hurricane loss costs provided in Form S-5, Average Annual Zero Deductible Statewide Hurricane Loss Costs – Historical versus Modeled, based on the 2017 FHCF Exposure Data.

B. ***If additional assumptions are necessary to complete this form, provide the rationale for the assumptions as well as a detailed description of how they are included.***

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, Base Hurricane Storm Set Statewide Hurricane Losses, in a submission appendix.***

The 2017 FHCF aggregate exposure data has been modeled with a zero-deductible assumption. The gross modeled loss from each specific hurricane in the Base Hurricane Storm Set is provided in Form A-2 in Table 45 and in and in Excel format. Total dollar contributions agree with the total average annual zero deductible statewide loss costs provided in Form S-5, Part D.

No additional assumptions were made to complete Form A-2.

Form A-2 was prepared using an automated process designed to limit the amount of manual intervention and decrease time and diligence. During the automation process, AIR exercised due diligence verifying that the process reproduced the same indications as those figures in Forms A-2 from prior submissions.

Table 45. Base Hurricane Storm Set Statewide Losses (2017 FHCF Exposure Data)

See next page

Form A-2: Base Hurricane Storm Set Statewide Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ID	Hurricane Landfall/ Closest Approach Date	Year	Name	Region as defined in Figure 3 - Category	Personal and Commercial Residential Insured Hurricane Losses ($)	Dollar Contribution*
001	253	1900	NoName01-1900	ByP-1	289,531	2,433
005	593	1901	NoName04-1901	F-1	123,882,572	1,041,030
010	1350	1903	NoName03-1903	C-1/A-1	2,969,228,438	24,951,499
015	1752	1904	NoName04-1904	C-1	873,692,821	7,341,956
020	2360	1906	NoName02-1906	C-1	1,072,777,942	9,014,941
025	2462	1906	NoName06-1906	F-1	128,120,686	1,076,644
030	2483	1906	NoName08-1906	C-3	3,282,978,395	27,588,054
035	3572	1909	NoName11-1909	B-3	840,267,849	7,061,074
040	3944	1910	NoName05-1910	B-3	8,049,018,792	67,638,813
045	4241	1911	NoName02-1911	F-1	477,055,074	4,008,866
050	4641	1912	NoName04-1912	F-1	349,049,949	2,933,193
055	5692	1915	NoName01-1915	D-1	178,549,913	1,500,419
060	5726	1915	NoName04-1915	A-1	58,915,310	495,087
065	6031	1916	NoName02-1916	F-3	102,747,508	863,424
070	6136	1916	NoName14-1916	A-2	496,088,317	4,168,809
075	6482	1917	NoName04-1917	A-3	2,627,444,151	22,079,363
080	7193	1919	NoName02-1919	ByP-4	512,550,033	4,307,143
085	7969	1921	TampaBay06-1921	B-3	9,137,287,136	76,783,926
090	9025	1924	NoName05-1924	A-1	83,802,208	704,220
095	9061	1924	NoName10-1924	B-1	660,446,171	5,549,968
096	9468	1925	NoName04-1925	ByP-1	352,632,526	2,963,299
100	9706	1926	NoName01-1926	D-3	2,855,638,521	23,996,962
105	9758	1926	GreatMiami07-1926	C-4/A-3	52,039,779,681	437,309,073
110	9791	1926	NoName10-1926	ByP-2	170,198,181	1,430,237
115	10448	1928	NoName01-1928	C-2	1,539,341,875	12,935,646
120	10488	1928	LakeOkeechobee04-1928	C-4	42,803,650,423	359,694,541
125	10864	1929	NoName02-1929	B-3/A-2	7,050,018,295	59,243,851
126	11214	1930	NoName02-1930	ByP-0	5,016,684	42,157
130	11933	1932	NoName03-1932	F-1	638,957,701	5,369,392
135	12265	1933	NoName05-1933	C-1	417,733,515	3,510,366
140	12301	1933	NoName11-1933	C-3	6,434,751,646	54,073,543
141	12302	1933	NoName08-1933	ByP-2	2,341,699	19,678
142	12332	1933	NoName17-1933	ByP-3	59,768,371	502,255
143	12625	1934	NoName03-1934	ByP-0	26,125,500	219,542
145	13030	1935	LaborDay03-1935	C-5/A-2	11,373,641,355	95,576,818
146	13056	1935	NoName05-1935	ByP-4	903,151,673	7,589,510
150	13092	1935	NoName07-1935	C-2	1,910,451,847	16,054,217
155	13362	1936	NoName05-1936	A-2	1,103,934,984	9,276,765
160	14468	1939	NoName02-1939	C-1/A-1	874,997,526	7,352,920
161	14830	1940	NoName02-1940	ByP-0	796,351	6,692
165	15255	1941	NoName05-1941	C-1/A-1	1,714,639,063	14,408,732
170	16364	1944	NoName13-1944	B-2	10,690,983,364	89,840,196
175	16612	1945	NoName01-1945	A-1	1,469,216,205	12,346,355
180	16695	1945	NoName09-1945	C-4	10,864,068,742	91,294,695
185	17083	1946	NoName06-1946	B-1	1,585,303,846	13,321,881
186	17403	1947	NoName03-1947	ByP-0	3,060,447	25,718
190	17427	1947	NoName04-1947	C-4/F-3	25,921,016,937	217,823,672
195	17452	1947	NoName09-1947	B-2/E-2	940,129,153	7,900,245
200	17798	1948	NoName08-1948	B-4	15,509,031,716	130,327,998
205	17811	1948	NoName09-1948	C-1	740,989,533	6,226,803
210	18136	1949	NoName02-1949	C-3	13,967,065,886	117,370,302
215	18506	1950	Baker-1950	F-2	169,179,154	1,421,674
220	18511	1950	Easy-1950	A-3	5,202,711,197	43,720,262
225	18554	1950	King-1950	C-3	5,400,066,130	45,378,707
226	18769	1951	Able-1951	ByP-1	1,316,231	11,061
227	18905	1951	How-1951	ByP-0	339,333,096	2,851,539

Form A-2: Base Hurricane Storm Set Statewide Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ID	Hurricane Landfall/ Closest Approach Date	Year	Name	Region as defined in Figure 3 - Category	Personal and Commercial Residential Insured Hurricane Losses ($)	Dollar Contribution*
228	19237	1952	Able-1952	ByP-1	0	0
230	19628	1953	Florence-1953	A-1	235,673,745	1,980,452
235	19641	1953	Hazel-1953	B-1	828,644,990	6,963,403
240	20723	1956	Flossy-1956	F-1/A-1	513,034,681	4,311,216
245	22169	1960	Donna-1960	B-3	18,634,347,959	156,591,159
250	22174	1960	Ethel-1960	F-1	0	0
251	23313	1963	Ginny-1963	ByP-1	0	0
255	23616	1964	Cleo-1964	C-2	4,850,576,965	40,761,151
260	23630	1964	Dora-1964	D-2	5,392,496,544	45,315,097
261	23652	1964	Hilda-1964	ByP-0	20,375,345	171,221
265	23664	1964	Isbell-1964	B-2	1,419,361,410	11,927,407
270	23993	1965	Betsy-1965	B-4	8,614,548,136	72,391,161
275	24267	1966	Alma-1966	A-1	201,459,669	1,692,938
280	24384	1966	Inez-1966	C-1	103,594,252	870,540
281	24993	1968	Abby-1968	ByP-1	372,093,602	3,126,837
285	25130	1968	Gladys-1968	A-1	1,873,010,788	15,739,586
290	25433	1969	Camille-1969	F-5	22,328,428	187,634
295	26469	1972	Agnes-1972	A-1	55,863,616	469,442
300	27660	1975	Eloise-1975	A-3	663,051,491	5,571,861
305	29102	1979	David-1979	C-1/E-2	3,000,707,787	25,216,032
310	29111	1979	Frederic-1979	F-3	776,541,949	6,525,563
315	31292	1985	Elena-1985	F-3	708,147,669	5,950,821
316	31349	1985	Juan-1985	ByP-1	314,209,502	2,640,416
320	31372	1985	Kate-1985	A-2	417,864,680	3,511,468
325	32062	1987	Floyd-1987	C-1	27,465,106	230,799
326	32396	1988	Florence-1988	F-1	0	0
330	33840	1992	Andrew-1992	C-5	23,237,637,461	195,274,264
331	34656	1994	Gordon-1994	ByP-0	220,805,190	1,855,506
335	34914	1995	Erin-1995	C-1/A-1	1,156,105,633	9,715,173
340	34976	1995	Opal-1995	A-3	2,084,862,770	17,519,855
345	35630	1997	Danny-1997	F-1	44,274,126	372,051
350	36041	1998	Earl-1998	A-1	57,628,555	484,274
355	36063	1998	Georges-1998	F-2	123,331,076	1,036,396
360	36448	1999	Irene-1999	B-1	240,825,369	2,023,743
361	36786	2000	Gordon-2000	ByP-1	156,507,839	1,315,192
365	38212	2004	Charley-2004	B-4	6,908,669,375	58,056,045
370	38235	2004	Frances-2004	C-1	6,216,419,818	52,238,822
375	38246	2004	Ivan-2004	F-3	2,233,484,719	18,768,779
380	38256	2004	Jeanne-2004	C-2	4,504,689,867	37,854,537
381	38539	2005	Cindy-2005	ByP-0	315,198	2,649
385	38543	2005	Dennis-2005	A-3	929,730,522	7,812,862
390	38589	2005	Katrina-2005	C-1	668,789,780	5,620,082
391	38610	2005	Ophelia-2005	ByP-1	1,071,445	9,004
395	38615	2005	Rita-2005	ByP-2	4,952,353	41,616
400	38649	2005	Wilma-2005	B-3	10,247,858,215	86,116,456
401	39704	2008	Ike-2008	ByP-0	275,527	2,315
402	41150	2012	Isaac-2012	ByP-0	1,029,331	8,650
405	42615	2016	Hermine-2016	A-1	7,976,701	67,031
410	42650	2016	Matthew-2016	ByP-4	675,070,728	5,672,863
415	42988	2017	Irma-2017	B-2	10,218,948,957	85,873,521
420	43016	2017	Nate-2017	F-1	1,628,853	13,688
425	43383	2018	Michael-2018	A-5	4,511,184,210	37,909,111
			Total		380,604,703,785	3,198,358,855

Form A-3: Hurricane Losses

A. One or more automated programs or scripts shall be used to generate and arrange the data in Form A-3, Hurricane Losses.

B. Provide the percentage of residential zero deductible hurricane losses, rounded to four decimal places, and the monetary contribution from Hurricane Hermine (2016), Hurricane Matthew (2016), Hurricane Irma (2017), and Hurricane Michael (2018) for each affected ZIP Code. Include all ZIP Codes where hurricane losses are equal to or greater than $500,000.

Use the 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data provided in the file named "hlpm2017c.zip."

Rather than using directly a specified published windfield, the winds underlying the hurricane loss cost calculations must be produced by the hurricane model being evaluated and should be the same hurricane parameters as used in completing Form A-2, Base Hurricane Storm Set Statewide Hurricane Losses.

A hard copy of Form A-3 is included in this submission appendix and is also provided in Excel. Form A-3 was prepared using an automated process designed to limit the amount of manual intervention and decrease time and diligence. During the automation process, AIR exercised due diligence verifying that the process reproduced the same indications as Form A-3 in prior submissions.

Table 46. Form A-3: Percentage of Total Personal and Commercial Residential Losses

See below

Note: ZIP Codes where total losses are equal to or greater than $500,000 are shown.

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
32003	0	0.0000%	1,974,481	0.2925%	6,740,230	0.0660%	0	0.0000%
32008	0	0.0000%	0	0.0000%	1,399,871	0.0137%	72,418	0.0016%
32009	0	0.0000%	0	0.0000%	624,331	0.0061%	0	0.0000%
32011	0	0.0000%	0	0.0000%	2,192,283	0.0215%	0	0.0000%
32024	0	0.0000%	0	0.0000%	7,244,004	0.0709%	128,364	0.0028%
32025	0	0.0000%	0	0.0000%	6,200,712	0.0607%	0	0.0000%
32033	0	0.0000%	982,974	0.1456%	606,663	0.0059%	0	0.0000%
32034	0	0.0000%	12,249,694	1.8146%	11,691,271	0.1144%	0	0.0000%
32038	0	0.0000%	0	0.0000%	3,210,051	0.0314%	0	0.0000%
32040	0	0.0000%	0	0.0000%	2,264,674	0.0222%	0	0.0000%
32043	0	0.0000%	1,012,767	0.1500%	4,361,543	0.0427%	0	0.0000%
32044	0	0.0000%	0	0.0000%	675,374	0.0066%	0	0.0000%
32046	0	0.0000%	0	0.0000%	1,373,603	0.0134%	0	0.0000%
32052	206,631	2.5904%	0	0.0000%	892,283	0.0087%	262,578	0.0058%
32053	183,039	2.2947%	0	0.0000%	468,706	0.0046%	253,534	0.0056%
32054	0	0.0000%	0	0.0000%	4,224,873	0.0413%	0	0.0000%
32055	0	0.0000%	0	0.0000%	4,259,395	0.0417%	105,849	0.0023%
32058	0	0.0000%	0	0.0000%	942,706	0.0092%	0	0.0000%
32059	215,943	2.7072%	0	0.0000%	286,801	0.0028%	257,117	0.0057%
32060	880,809	11.0423%	0	0.0000%	4,185,868	0.0410%	1,324,501	0.0294%
32062	61,587	0.7721%	0	0.0000%	516,172	0.0051%	102,970	0.0023%
32063	0	0.0000%	0	0.0000%	2,919,589	0.0286%	0	0.0000%
32064	152,405	1.9106%	0	0.0000%	840,756	0.0082%	223,977	0.0050%
32065	0	0.0000%	568,971	0.0843%	6,191,404	0.0606%	0	0.0000%
32066	181,418	2.2743%	0	0.0000%	599,951	0.0059%	221,135	0.0049%
32068	0	0.0000%	666,173	0.0987%	10,325,878	0.1010%	0	0.0000%
32071	14,548	0.1824%	0	0.0000%	847,621	0.0083%	106,345	0.0024%
32073	0	0.0000%	1,296,964	0.1921%	9,098,058	0.0890%	0	0.0000%
32080	0	0.0000%	19,589,983	2.9019%	7,695,560	0.0753%	0	0.0000%
32081	0	0.0000%	3,376,429	0.5002%	1,835,108	0.0180%	0	0.0000%
32082	0	0.0000%	45,143,064	6.6872%	16,323,953	0.1597%	0	0.0000%
32084	0	0.0000%	10,698,073	1.5847%	3,610,908	0.0353%	0	0.0000%
32086	0	0.0000%	9,069,973	1.3436%	3,639,844	0.0356%	0	0.0000%
32087	0	0.0000%	0	0.0000%	1,056,701	0.0103%	0	0.0000%
32091	0	0.0000%	0	0.0000%	4,480,959	0.0438%	0	0.0000%
32092	0	0.0000%	3,963,367	0.5871%	4,435,997	0.0434%	0	0.0000%
32094	11,395	0.1429%	0	0.0000%	936,491	0.0092%	95,808	0.0021%
32095	0	0.0000%	3,285,273	0.4867%	1,418,283	0.0139%	0	0.0000%
32096	17,856	0.2239%	0	0.0000%	695,950	0.0068%	55,246	0.0012%
32097	0	0.0000%	1,121,484	0.1661%	1,876,730	0.0184%	0	0.0000%
32102	0	0.0000%	622,387	0.0922%	704,506	0.0069%	0	0.0000%
32110	0	0.0000%	1,053,513	0.1561%	596,897	0.0058%	0	0.0000%
32112	0	0.0000%	726,877	0.1077%	1,389,654	0.0136%	0	0.0000%
32113	0	0.0000%	0	0.0000%	2,930,704	0.0287%	0	0.0000%
32114	0	0.0000%	4,625,132	0.6851%	1,062,133	0.0104%	0	0.0000%
32117	0	0.0000%	5,839,999	0.8651%	1,373,009	0.0134%	0	0.0000%
32118	0	0.0000%	9,170,270	1.3584%	2,257,768	0.0221%	0	0.0000%
32119	0	0.0000%	8,032,823	1.1899%	1,767,624	0.0173%	0	0.0000%
32124	0	0.0000%	759,774	0.1125%	263,952	0.0026%	0	0.0000%
32127	0	0.0000%	15,643,559	2.3173%	2,966,873	0.0290%	0	0.0000%
32128	0	0.0000%	6,453,903	0.9560%	1,539,386	0.0151%	0	0.0000%
32129	0	0.0000%	8,133,373	1.2048%	1,839,102	0.0180%	0	0.0000%
32130	0	0.0000%	583,517	0.0864%	521,592	0.0051%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	**Hurricane Hermine (2016)**		**Hurricane Matthew (2016)**		**Hurricane Irma (2017)**		**Hurricane Michael (2018)**	
	Personal & Commercial Residential Monetary Contribution ($)	**Percent of Losses (%)**	**Personal & Commercial Residential Monetary Contribution ($)**	**Percent of Losses (%)**	**Personal & Commercial Residential Monetary Contribution ($)**	**Percent of Losses (%)**	**Personal & Commercial Residential Monetary Contribution ($)**	**Percent of Losses (%)**
32131	0	0.0000%	441,026	0.0653%	649,591	0.0064%	0	0.0000%
32132	0	0.0000%	3,514,579	0.5206%	679,988	0.0067%	0	0.0000%
32134	0	0.0000%	81,667	0.0121%	2,247,972	0.0220%	0	0.0000%
32136	0	0.0000%	7,328,935	1.0857%	2,099,596	0.0205%	0	0.0000%
32137	0	0.0000%	19,247,384	2.8512%	5,361,121	0.0525%	0	0.0000%
32139	0	0.0000%	156,383	0.0232%	791,330	0.0077%	0	0.0000%
32141	0	0.0000%	9,623,877	1.4256%	2,175,993	0.0213%	0	0.0000%
32145	0	0.0000%	656,667	0.0973%	499,123	0.0049%	0	0.0000%
32148	0	0.0000%	161,686	0.0240%	2,296,849	0.0225%	0	0.0000%
32159	0	0.0000%	0	0.0000%	40,849,256	0.3997%	0	0.0000%
32162	0	0.0000%	0	0.0000%	43,812,770	0.4287%	0	0.0000%
32163	0	0.0000%	0	0.0000%	13,701,646	0.1341%	0	0.0000%
32164	0	0.0000%	7,825,009	1.1591%	2,755,862	0.0270%	0	0.0000%
32168	0	0.0000%	9,199,010	1.3627%	1,621,242	0.0159%	0	0.0000%
32169	0	0.0000%	12,092,373	1.7913%	2,445,856	0.0239%	0	0.0000%
32174	0	0.0000%	22,189,300	3.2870%	5,754,831	0.0563%	0	0.0000%
32176	0	0.0000%	12,832,155	1.9009%	3,247,291	0.0318%	0	0.0000%
32177	0	0.0000%	1,203,639	0.1783%	3,499,971	0.0342%	0	0.0000%
32179	0	0.0000%	0	0.0000%	3,685,338	0.0361%	0	0.0000%
32180	0	0.0000%	301,741	0.0447%	348,549	0.0034%	0	0.0000%
32181	0	0.0000%	262,674	0.0389%	613,272	0.0060%	0	0.0000%
32187	0	0.0000%	215,641	0.0319%	333,326	0.0033%	0	0.0000%
32189	0	0.0000%	622,735	0.0922%	1,536,497	0.0150%	0	0.0000%
32193	0	0.0000%	116,302	0.0172%	398,937	0.0039%	0	0.0000%
32195	0	0.0000%	0	0.0000%	2,325,416	0.0228%	0	0.0000%
32204	0	0.0000%	215,398	0.0319%	1,111,300	0.0109%	0	0.0000%
32205	0	0.0000%	826,146	0.1224%	5,972,140	0.0584%	0	0.0000%
32206	0	0.0000%	365,490	0.0541%	1,314,090	0.0129%	0	0.0000%
32207	0	0.0000%	2,206,173	0.3268%	5,995,040	0.0587%	0	0.0000%
32208	0	0.0000%	503,552	0.0746%	2,667,837	0.0261%	0	0.0000%
32209	0	0.0000%	376,188	0.0557%	2,062,858	0.0202%	0	0.0000%
32210	0	0.0000%	1,061,837	0.1573%	10,616,899	0.1039%	0	0.0000%
32211	0	0.0000%	1,891,938	0.2803%	2,410,499	0.0236%	0	0.0000%
32216	0	0.0000%	2,228,649	0.3301%	3,263,673	0.0319%	0	0.0000%
32217	0	0.0000%	1,547,380	0.2292%	3,404,261	0.0333%	0	0.0000%
32218	0	0.0000%	1,367,995	0.2026%	6,016,705	0.0589%	0	0.0000%
32219	0	0.0000%	66,624	0.0099%	1,446,999	0.0142%	0	0.0000%
32220	0	0.0000%	72,414	0.0107%	1,959,445	0.0192%	0	0.0000%
32221	0	0.0000%	175,512	0.0260%	4,236,087	0.0415%	0	0.0000%
32222	0	0.0000%	108,643	0.0161%	1,652,257	0.0162%	0	0.0000%
32223	0	0.0000%	3,350,134	0.4963%	6,276,676	0.0614%	0	0.0000%
32224	0	0.0000%	6,591,849	0.9765%	3,889,499	0.0381%	0	0.0000%
32225	0	0.0000%	9,101,366	1.3482%	6,059,234	0.0593%	0	0.0000%
32226	0	0.0000%	1,807,728	0.2678%	2,246,512	0.0220%	0	0.0000%
32233	0	0.0000%	11,127,641	1.6484%	5,207,643	0.0510%	0	0.0000%
32234	0	0.0000%	0	0.0000%	1,385,832	0.0136%	0	0.0000%
32244	0	0.0000%	1,049,759	0.1555%	9,423,020	0.0922%	0	0.0000%
32246	0	0.0000%	4,260,161	0.6311%	3,629,571	0.0355%	0	0.0000%
32250	0	0.0000%	14,234,036	2.1085%	6,129,682	0.0600%	0	0.0000%
32254	0	0.0000%	125,835	0.0186%	1,022,266	0.0100%	0	0.0000%
32256	0	0.0000%	3,168,389	0.4693%	3,786,348	0.0371%	0	0.0000%
32257	0	0.0000%	3,184,511	0.4717%	5,745,719	0.0562%	0	0.0000%
32258	0	0.0000%	2,696,388	0.3994%	3,523,645	0.0345%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
32259	0	0.0000%	4,839,398	0.7169%	8,356,616	0.0818%	0	0.0000%
32266	0	0.0000%	5,492,048	0.8136%	2,431,377	0.0238%	0	0.0000%
32277	0	0.0000%	1,519,728	0.2251%	2,782,095	0.0272%	0	0.0000%
32301	283,903	3.5592%	0	0.0000%	407,509	0.0040%	15,437,527	0.3422%
32303	317,905	3.9854%	0	0.0000%	779,993	0.0076%	45,370,495	1.0057%
32304	115,543	1.4485%	0	0.0000%	236,712	0.0023%	11,409,208	0.2529%
32305	212,327	2.6618%	0	0.0000%	310,523	0.0030%	9,245,197	0.2049%
32308	198,270	2.4856%	0	0.0000%	509,937	0.0050%	23,134,725	0.5128%
32309	307,331	3.8529%	0	0.0000%	964,781	0.0094%	38,347,507	0.8501%
32310	72,839	0.9131%	0	0.0000%	165,644	0.0016%	9,574,510	0.2122%
32311	257,459	3.2276%	0	0.0000%	547,913	0.0054%	12,861,582	0.2851%
32312	192,696	2.4157%	0	0.0000%	1,136,632	0.0111%	56,490,746	1.2522%
32317	170,085	2.1323%	0	0.0000%	469,944	0.0046%	12,969,908	0.2875%
32320	36,854	0.4620%	0	0.0000%	0	0.0000%	14,933,465	0.3310%
32321	0	0.0000%	0	0.0000%	10,328	0.0001%	34,496,008	0.7647%
32322	76,052	0.9534%	0	0.0000%	0	0.0000%	7,322,457	0.1623%
32324	0	0.0000%	0	0.0000%	62,749	0.0006%	25,973,242	0.5758%
32327	457,910	5.7406%	0	0.0000%	338,070	0.0033%	15,227,615	0.3376%
32328	144,096	1.8065%	0	0.0000%	0	0.0000%	29,268,854	0.6488%
32330	0	0.0000%	0	0.0000%	785	0.0000%	2,079,689	0.0461%
32331	138,687	1.7387%	0	0.0000%	238,704	0.0023%	718,383	0.0159%
32332	0	0.0000%	0	0.0000%	5,702	0.0001%	6,126,411	0.1358%
32333	0	0.0000%	0	0.0000%	228,213	0.0022%	16,601,414	0.3680%
32334	0	0.0000%	0	0.0000%	0	0.0000%	11,212,686	0.2486%
32340	557,644	6.9909%	0	0.0000%	846,555	0.0083%	1,153,049	0.0256%
32343	0	0.0000%	0	0.0000%	16,593	0.0002%	2,278,338	0.0505%
32344	253,280	3.1752%	0	0.0000%	597,177	0.0058%	4,744,296	0.1052%
32346	216,538	2.7146%	0	0.0000%	19,853	0.0002%	3,586,682	0.0795%
32347	633,243	7.9387%	0	0.0000%	566,928	0.0055%	997,460	0.0221%
32348	673,790	8.4470%	0	0.0000%	683,084	0.0067%	900,730	0.0200%
32351	0	0.0000%	0	0.0000%	142,269	0.0014%	87,901,194	1.9485%
32352	0	0.0000%	0	0.0000%	62,821	0.0006%	38,809,978	0.8603%
32358	13,153	0.1649%	0	0.0000%	15,016	0.0001%	2,305,657	0.0511%
32359	363,411	4.5559%	0	0.0000%	668,167	0.0065%	458,700	0.0102%
32401	0	0.0000%	0	0.0000%	0	0.0000%	233,475,242	5.1755%
32403	0	0.0000%	0	0.0000%	0	0.0000%	2,414,353	0.0535%
32404	0	0.0000%	0	0.0000%	0	0.0000%	511,762,803	11.3443%
32405	0	0.0000%	0	0.0000%	0	0.0000%	462,201,228	10.2457%
32407	0	0.0000%	0	0.0000%	0	0.0000%	202,122,225	4.4805%
32408	0	0.0000%	0	0.0000%	0	0.0000%	666,463,357	14.7736%
32409	0	0.0000%	0	0.0000%	0	0.0000%	81,223,269	1.8005%
32413	0	0.0000%	0	0.0000%	0	0.0000%	41,512,574	0.9202%
32420	0	0.0000%	0	0.0000%	0	0.0000%	15,615,182	0.3461%
32421	0	0.0000%	0	0.0000%	0	0.0000%	28,489,895	0.6315%
32423	0	0.0000%	0	0.0000%	4,691	0.0000%	5,848,597	0.1296%
32424	0	0.0000%	0	0.0000%	0	0.0000%	46,899,386	1.0396%
32425	0	0.0000%	0	0.0000%	0	0.0000%	4,318,072	0.0957%
32426	0	0.0000%	0	0.0000%	0	0.0000%	3,373,474	0.0748%
32428	0	0.0000%	0	0.0000%	0	0.0000%	65,548,256	1.4530%
32430	0	0.0000%	0	0.0000%	0	0.0000%	10,525,480	0.2333%
32431	0	0.0000%	0	0.0000%	0	0.0000%	22,756,202	0.5044%
32433	0	0.0000%	0	0.0000%	0	0.0000%	1,654,117	0.0367%
32435	0	0.0000%	0	0.0000%	0	0.0000%	981,650	0.0218%

Form A-3: Hurricane Losses

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
32438	0	0.0000%	0	0.0000%	0	0.0000%	20,184,063	0.4474%
32439	0	0.0000%	0	0.0000%	0	0.0000%	2,783,579	0.0617%
32440	0	0.0000%	0	0.0000%	0	0.0000%	4,435,286	0.0983%
32442	0	0.0000%	0	0.0000%	21,759	0.0002%	32,326,679	0.7166%
32443	0	0.0000%	0	0.0000%	11,587	0.0001%	14,502,156	0.3215%
32444	0	0.0000%	0	0.0000%	0	0.0000%	335,998,276	7.4481%
32445	0	0.0000%	0	0.0000%	4,541	0.0000%	7,257,506	0.1609%
32446	0	0.0000%	0	0.0000%	36,963	0.0004%	71,298,072	1.5805%
32448	0	0.0000%	0	0.0000%	0	0.0000%	40,496,569	0.8977%
32449	0	0.0000%	0	0.0000%	0	0.0000%	3,504,205	0.0777%
32455	0	0.0000%	0	0.0000%	0	0.0000%	877,667	0.0195%
32456	0	0.0000%	0	0.0000%	0	0.0000%	838,327,738	18.5833%
32459	0	0.0000%	0	0.0000%	0	0.0000%	21,063,328	0.4669%
32460	0	0.0000%	0	0.0000%	24,694	0.0002%	23,594,021	0.5230%
32461	0	0.0000%	0	0.0000%	0	0.0000%	1,934,643	0.0429%
32462	0	0.0000%	0	0.0000%	0	0.0000%	1,487,179	0.0330%
32464	0	0.0000%	0	0.0000%	0	0.0000%	621,079	0.0138%
32465	0	0.0000%	0	0.0000%	0	0.0000%	70,411,427	1.5608%
32466	0	0.0000%	0	0.0000%	0	0.0000%	31,475,248	0.6977%
32536	0	0.0000%	0	0.0000%	0	0.0000%	635,837	0.0141%
32539	0	0.0000%	0	0.0000%	0	0.0000%	895,314	0.0198%
32541	0	0.0000%	0	0.0000%	0	0.0000%	8,571,037	0.1900%
32547	0	0.0000%	0	0.0000%	0	0.0000%	2,070,679	0.0459%
32548	0	0.0000%	0	0.0000%	0	0.0000%	2,011,387	0.0446%
32550	0	0.0000%	0	0.0000%	0	0.0000%	8,107,849	0.1797%
32561	0	0.0000%	0	0.0000%	0	0.0000%	877,658	0.0195%
32563	0	0.0000%	0	0.0000%	0	0.0000%	1,702,121	0.0377%
32566	0	0.0000%	0	0.0000%	0	0.0000%	1,072,915	0.0238%
32569	0	0.0000%	0	0.0000%	0	0.0000%	766,325	0.0170%
32578	0	0.0000%	0	0.0000%	0	0.0000%	5,067,218	0.1123%
32579	0	0.0000%	0	0.0000%	0	0.0000%	1,490,204	0.0330%
32601	0	0.0000%	0	0.0000%	5,612,170	0.0549%	0	0.0000%
32603	0	0.0000%	0	0.0000%	1,231,459	0.0121%	0	0.0000%
32605	0	0.0000%	0	0.0000%	16,182,038	0.1584%	0	0.0000%
32606	0	0.0000%	0	0.0000%	13,072,067	0.1279%	0	0.0000%
32607	0	0.0000%	0	0.0000%	12,013,122	0.1176%	0	0.0000%
32608	0	0.0000%	0	0.0000%	18,987,022	0.1858%	0	0.0000%
32609	0	0.0000%	0	0.0000%	5,466,973	0.0535%	0	0.0000%
32615	0	0.0000%	0	0.0000%	7,513,427	0.0735%	0	0.0000%
32617	0	0.0000%	0	0.0000%	1,898,668	0.0186%	0	0.0000%
32618	0	0.0000%	0	0.0000%	3,278,724	0.0321%	0	0.0000%
32619	0	0.0000%	0	0.0000%	1,080,893	0.0106%	0	0.0000%
32621	0	0.0000%	0	0.0000%	1,403,630	0.0137%	0	0.0000%
32622	0	0.0000%	0	0.0000%	584,710	0.0057%	0	0.0000%
32625	53,643	0.6725%	0	0.0000%	810,995	0.0079%	135,784	0.0030%
32626	0	0.0000%	0	0.0000%	1,828,810	0.0179%	0	0.0000%
32640	0	0.0000%	0	0.0000%	3,938,439	0.0385%	0	0.0000%
32641	0	0.0000%	0	0.0000%	3,221,065	0.0315%	0	0.0000%
32643	0	0.0000%	0	0.0000%	4,455,235	0.0436%	0	0.0000%
32653	0	0.0000%	0	0.0000%	9,833,029	0.0962%	0	0.0000%
32656	0	0.0000%	99,495	0.0147%	4,555,394	0.0446%	0	0.0000%
32666	0	0.0000%	26,061	0.0039%	2,523,433	0.0247%	0	0.0000%
32667	0	0.0000%	0	0.0000%	3,910,249	0.0383%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
32668	0	0.0000%	0	0.0000%	2,692,732	0.0264%	0	0.0000%
32669	0	0.0000%	0	0.0000%	6,585,943	0.0644%	0	0.0000%
32680	65,208	0.8175%	0	0.0000%	1,580,802	0.0155%	0	0.0000%
32686	0	0.0000%	0	0.0000%	3,782,199	0.0370%	0	0.0000%
32693	0	0.0000%	0	0.0000%	2,641,582	0.0258%	0	0.0000%
32694	0	0.0000%	0	0.0000%	708,695	0.0069%	0	0.0000%
32696	0	0.0000%	0	0.0000%	5,198,496	0.0509%	0	0.0000%
32701	0	0.0000%	543,009	0.0804%	3,513,218	0.0344%	0	0.0000%
32702	0	0.0000%	41,782	0.0062%	796,810	0.0078%	0	0.0000%
32703	0	0.0000%	521,324	0.0772%	8,898,289	0.0871%	0	0.0000%
32707	0	0.0000%	1,570,645	0.2327%	5,638,499	0.0552%	0	0.0000%
32708	0	0.0000%	3,530,375	0.5230%	8,692,571	0.0851%	0	0.0000%
32709	0	0.0000%	373,492	0.0553%	269,451	0.0026%	0	0.0000%
32712	0	0.0000%	896,476	0.1328%	14,665,337	0.1435%	0	0.0000%
32713	0	0.0000%	2,491,650	0.3691%	4,428,416	0.0433%	0	0.0000%
32714	0	0.0000%	605,354	0.0897%	5,872,676	0.0575%	0	0.0000%
32720	0	0.0000%	3,392,784	0.5026%	3,334,191	0.0326%	0	0.0000%
32724	0	0.0000%	4,884,241	0.7235%	3,757,549	0.0368%	0	0.0000%
32725	0	0.0000%	5,054,215	0.7487%	6,151,132	0.0602%	0	0.0000%
32726	0	0.0000%	307,346	0.0455%	8,430,695	0.0825%	0	0.0000%
32730	0	0.0000%	160,039	0.0237%	764,585	0.0075%	0	0.0000%
32732	0	0.0000%	1,318,256	0.1953%	890,392	0.0087%	0	0.0000%
32735	0	0.0000%	27,148	0.0040%	3,051,927	0.0299%	0	0.0000%
32736	0	0.0000%	362,530	0.0537%	3,205,276	0.0314%	0	0.0000%
32738	0	0.0000%	5,390,242	0.7985%	4,211,201	0.0412%	0	0.0000%
32744	0	0.0000%	573,948	0.0850%	421,462	0.0041%	0	0.0000%
32746	0	0.0000%	3,079,211	0.4561%	10,002,882	0.0979%	0	0.0000%
32750	0	0.0000%	1,171,753	0.1736%	5,109,735	0.0500%	0	0.0000%
32751	0	0.0000%	971,350	0.1439%	6,350,649	0.0621%	0	0.0000%
32754	0	0.0000%	2,864,924	0.4244%	934,045	0.0091%	0	0.0000%
32757	0	0.0000%	581,229	0.0861%	11,090,953	0.1085%	0	0.0000%
32759	0	0.0000%	1,280,518	0.1897%	328,988	0.0032%	0	0.0000%
32763	0	0.0000%	1,910,598	0.2830%	2,502,554	0.0245%	0	0.0000%
32764	0	0.0000%	673,133	0.0997%	450,431	0.0044%	0	0.0000%
32765	0	0.0000%	5,904,730	0.8747%	9,229,618	0.0903%	0	0.0000%
32766	0	0.0000%	2,173,749	0.3220%	2,132,243	0.0209%	0	0.0000%
32767	0	0.0000%	122,470	0.0181%	482,800	0.0047%	0	0.0000%
32771	0	0.0000%	3,268,338	0.4841%	6,770,970	0.0663%	0	0.0000%
32773	0	0.0000%	1,761,339	0.2609%	3,015,518	0.0295%	0	0.0000%
32776	0	0.0000%	342,039	0.0507%	2,905,429	0.0284%	0	0.0000%
32778	0	0.0000%	134,998	0.0200%	16,103,269	0.1576%	0	0.0000%
32779	0	0.0000%	1,558,729	0.2309%	12,548,825	0.1228%	0	0.0000%
32780	0	0.0000%	10,331,347	1.5304%	3,318,724	0.0325%	0	0.0000%
32784	0	0.0000%	44,161	0.0065%	4,064,093	0.0398%	0	0.0000%
32789	0	0.0000%	1,609,874	0.2385%	11,654,642	0.1140%	0	0.0000%
32792	0	0.0000%	1,603,214	0.2375%	6,675,162	0.0653%	0	0.0000%
32796	0	0.0000%	5,983,973	0.8864%	1,898,006	0.0186%	0	0.0000%
32798	0	0.0000%	168,500	0.0250%	5,011,265	0.0490%	0	0.0000%
32801	0	0.0000%	75,901	0.0112%	1,893,849	0.0185%	0	0.0000%
32803	0	0.0000%	425,628	0.0630%	5,275,642	0.0516%	0	0.0000%
32804	0	0.0000%	449,951	0.0667%	6,439,809	0.0630%	0	0.0000%
32805	0	0.0000%	0	0.0000%	1,919,670	0.0188%	0	0.0000%
32806	0	0.0000%	167,735	0.0248%	7,389,187	0.0723%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
32807	0	0.0000%	546,779	0.0810%	3,371,456	0.0330%	0	0.0000%
32808	0	0.0000%	190,872	0.0283%	5,570,395	0.0545%	0	0.0000%
32809	0	0.0000%	0	0.0000%	4,246,433	0.0416%	0	0.0000%
32810	0	0.0000%	338,247	0.0501%	4,588,427	0.0449%	0	0.0000%
32811	0	0.0000%	0	0.0000%	2,981,764	0.0292%	0	0.0000%
32812	0	0.0000%	256,513	0.0380%	6,659,736	0.0652%	0	0.0000%
32814	0	0.0000%	214,895	0.0318%	1,332,379	0.0130%	0	0.0000%
32817	0	0.0000%	1,511,177	0.2239%	4,175,188	0.0409%	0	0.0000%
32818	0	0.0000%	271,952	0.0403%	7,976,956	0.0781%	0	0.0000%
32819	0	0.0000%	0	0.0000%	12,467,663	0.1220%	0	0.0000%
32820	0	0.0000%	801,064	0.1187%	1,028,993	0.0101%	0	0.0000%
32821	0	0.0000%	0	0.0000%	4,097,737	0.0401%	0	0.0000%
32822	0	0.0000%	737,145	0.1092%	6,450,415	0.0631%	0	0.0000%
32824	0	0.0000%	0	0.0000%	11,344,141	0.1110%	0	0.0000%
32825	0	0.0000%	1,876,613	0.2780%	7,344,580	0.0719%	0	0.0000%
32826	0	0.0000%	1,528,830	0.2265%	2,961,989	0.0290%	0	0.0000%
32827	0	0.0000%	0	0.0000%	4,343,610	0.0425%	0	0.0000%
32828	0	0.0000%	3,001,205	0.4446%	7,316,326	0.0716%	0	0.0000%
32829	0	0.0000%	370,564	0.0549%	2,687,048	0.0263%	0	0.0000%
32832	0	0.0000%	325,250	0.0482%	4,489,548	0.0439%	0	0.0000%
32833	0	0.0000%	799,809	0.1185%	1,252,942	0.0123%	0	0.0000%
32835	0	0.0000%	0	0.0000%	9,581,277	0.0938%	0	0.0000%
32836	0	0.0000%	0	0.0000%	11,946,658	0.1169%	0	0.0000%
32837	0	0.0000%	0	0.0000%	14,185,012	0.1388%	0	0.0000%
32839	0	0.0000%	0	0.0000%	3,851,144	0.0377%	0	0.0000%
32901	0	0.0000%	3,236,422	0.4794%	1,328,640	0.0130%	0	0.0000%
32903	0	0.0000%	7,098,162	1.0515%	3,061,828	0.0300%	0	0.0000%
32904	0	0.0000%	4,786,590	0.7091%	2,418,276	0.0237%	0	0.0000%
32905	0	0.0000%	3,445,522	0.5104%	1,460,034	0.0143%	0	0.0000%
32907	0	0.0000%	5,055,513	0.7489%	3,565,013	0.0349%	0	0.0000%
32908	0	0.0000%	920,339	0.1363%	849,877	0.0083%	0	0.0000%
32909	0	0.0000%	3,090,267	0.4578%	2,296,167	0.0225%	0	0.0000%
32920	0	0.0000%	3,176,918	0.4706%	1,771,694	0.0173%	0	0.0000%
32922	0	0.0000%	1,492,335	0.2211%	597,831	0.0059%	0	0.0000%
32926	0	0.0000%	4,879,503	0.7228%	2,143,426	0.0210%	0	0.0000%
32927	0	0.0000%	6,128,297	0.9078%	1,985,856	0.0194%	0	0.0000%
32931	0	0.0000%	6,796,045	1.0067%	3,612,498	0.0354%	0	0.0000%
32934	0	0.0000%	4,399,939	0.6518%	1,840,302	0.0180%	0	0.0000%
32935	0	0.0000%	7,753,716	1.1486%	2,850,620	0.0279%	0	0.0000%
32937	0	0.0000%	14,598,204	2.1625%	5,412,817	0.0530%	0	0.0000%
32940	0	0.0000%	10,316,686	1.5282%	4,221,971	0.0413%	0	0.0000%
32949	0	0.0000%	667,714	0.0989%	257,263	0.0025%	0	0.0000%
32950	0	0.0000%	1,140,863	0.1690%	465,166	0.0046%	0	0.0000%
32951	0	0.0000%	7,763,080	1.1500%	2,583,954	0.0253%	0	0.0000%
32952	0	0.0000%	7,583,992	1.1234%	3,778,547	0.0370%	0	0.0000%
32953	0	0.0000%	7,114,544	1.0539%	2,791,208	0.0273%	0	0.0000%
32955	0	0.0000%	9,021,046	1.3363%	4,247,308	0.0416%	0	0.0000%
32958	0	0.0000%	6,949,888	1.0295%	2,309,831	0.0226%	0	0.0000%
32960	0	0.0000%	2,868,458	0.4249%	1,225,137	0.0120%	0	0.0000%
32962	0	0.0000%	3,074,057	0.4554%	1,368,898	0.0134%	0	0.0000%
32963	0	0.0000%	13,591,655	2.0134%	4,501,027	0.0440%	0	0.0000%
32966	0	0.0000%	2,523,909	0.3739%	1,721,512	0.0168%	0	0.0000%
32967	0	0.0000%	2,973,041	0.4404%	1,212,847	0.0119%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
32968	0	0.0000%	1,880,821	0.2786%	1,066,973	0.0104%	0	0.0000%
32976	0	0.0000%	6,570,236	0.9733%	2,584,060	0.0253%	0	0.0000%
33004	0	0.0000%	0	0.0000%	3,934,044	0.0385%	0	0.0000%
33009	0	0.0000%	0	0.0000%	12,919,943	0.1264%	0	0.0000%
33010	0	0.0000%	0	0.0000%	4,246,855	0.0416%	0	0.0000%
33012	0	0.0000%	0	0.0000%	7,682,917	0.0752%	0	0.0000%
33013	0	0.0000%	0	0.0000%	3,953,775	0.0387%	0	0.0000%
33014	0	0.0000%	0	0.0000%	6,277,027	0.0614%	0	0.0000%
33015	0	0.0000%	0	0.0000%	9,074,328	0.0888%	0	0.0000%
33016	0	0.0000%	0	0.0000%	6,275,561	0.0614%	0	0.0000%
33018	0	0.0000%	0	0.0000%	7,414,177	0.0726%	0	0.0000%
33019	0	0.0000%	0	0.0000%	8,879,587	0.0869%	0	0.0000%
33020	0	0.0000%	0	0.0000%	7,871,399	0.0770%	0	0.0000%
33021	0	0.0000%	0	0.0000%	10,136,579	0.0992%	0	0.0000%
33023	0	0.0000%	0	0.0000%	9,186,575	0.0899%	0	0.0000%
33024	0	0.0000%	0	0.0000%	8,980,383	0.0879%	0	0.0000%
33025	0	0.0000%	0	0.0000%	8,123,722	0.0795%	0	0.0000%
33026	0	0.0000%	0	0.0000%	8,276,880	0.0810%	0	0.0000%
33027	0	0.0000%	0	0.0000%	12,958,318	0.1268%	0	0.0000%
33028	0	0.0000%	0	0.0000%	5,663,781	0.0554%	0	0.0000%
33029	0	0.0000%	0	0.0000%	17,621,015	0.1724%	0	0.0000%
33030	0	0.0000%	0	0.0000%	21,259,499	0.2080%	0	0.0000%
33031	0	0.0000%	0	0.0000%	10,184,259	0.0997%	0	0.0000%
33032	0	0.0000%	0	0.0000%	26,494,569	0.2593%	0	0.0000%
33033	0	0.0000%	0	0.0000%	27,629,335	0.2704%	0	0.0000%
33034	0	0.0000%	0	0.0000%	9,422,426	0.0922%	0	0.0000%
33035	0	0.0000%	0	0.0000%	7,491,891	0.0733%	0	0.0000%
33036	0	0.0000%	0	0.0000%	120,679,608	1.1809%	0	0.0000%
33037	0	0.0000%	0	0.0000%	186,135,342	1.8215%	0	0.0000%
33040	0	0.0000%	0	0.0000%	106,610,791	1.0433%	0	0.0000%
33042	0	0.0000%	0	0.0000%	34,955,838	0.3421%	0	0.0000%
33043	0	0.0000%	0	0.0000%	29,600,049	0.2897%	0	0.0000%
33050	0	0.0000%	0	0.0000%	111,501,334	1.0911%	0	0.0000%
33051	0	0.0000%	0	0.0000%	22,467,504	0.2199%	0	0.0000%
33054	0	0.0000%	0	0.0000%	2,603,460	0.0255%	0	0.0000%
33055	0	0.0000%	0	0.0000%	5,127,446	0.0502%	0	0.0000%
33056	0	0.0000%	0	0.0000%	4,173,433	0.0408%	0	0.0000%
33060	0	0.0000%	0	0.0000%	4,858,753	0.0475%	0	0.0000%
33062	0	0.0000%	0	0.0000%	7,977,936	0.0781%	0	0.0000%
33063	0	0.0000%	0	0.0000%	3,896,394	0.0381%	0	0.0000%
33064	0	0.0000%	0	0.0000%	8,266,808	0.0809%	0	0.0000%
33065	0	0.0000%	0	0.0000%	4,215,534	0.0413%	0	0.0000%
33066	0	0.0000%	0	0.0000%	1,659,197	0.0162%	0	0.0000%
33067	0	0.0000%	0	0.0000%	2,870,468	0.0281%	0	0.0000%
33068	0	0.0000%	0	0.0000%	2,769,570	0.0271%	0	0.0000%
33069	0	0.0000%	0	0.0000%	1,826,166	0.0179%	0	0.0000%
33070	0	0.0000%	0	0.0000%	106,509,177	1.0423%	0	0.0000%
33071	0	0.0000%	0	0.0000%	5,393,143	0.0528%	0	0.0000%
33073	0	0.0000%	0	0.0000%	1,448,388	0.0142%	0	0.0000%
33076	0	0.0000%	0	0.0000%	3,910,342	0.0383%	0	0.0000%
33109	0	0.0000%	0	0.0000%	5,299,499	0.0519%	0	0.0000%
33125	0	0.0000%	0	0.0000%	10,812,318	0.1058%	0	0.0000%
33126	0	0.0000%	0	0.0000%	9,122,791	0.0893%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
33127	0	0.0000%	0	0.0000%	3,845,431	0.0376%	0	0.0000%
33128	0	0.0000%	0	0.0000%	587,874	0.0058%	0	0.0000%
33129	0	0.0000%	0	0.0000%	11,875,286	0.1162%	0	0.0000%
33130	0	0.0000%	0	0.0000%	5,060,584	0.0495%	0	0.0000%
33131	0	0.0000%	0	0.0000%	7,892,982	0.0772%	0	0.0000%
33132	0	0.0000%	0	0.0000%	2,598,905	0.0254%	0	0.0000%
33133	0	0.0000%	0	0.0000%	46,663,301	0.4566%	0	0.0000%
33134	0	0.0000%	0	0.0000%	33,460,933	0.3274%	0	0.0000%
33135	0	0.0000%	0	0.0000%	8,747,888	0.0856%	0	0.0000%
33136	0	0.0000%	0	0.0000%	1,625,342	0.0159%	0	0.0000%
33137	0	0.0000%	0	0.0000%	5,736,751	0.0561%	0	0.0000%
33138	0	0.0000%	0	0.0000%	9,918,143	0.0971%	0	0.0000%
33139	0	0.0000%	0	0.0000%	25,614,199	0.2507%	0	0.0000%
33140	0	0.0000%	0	0.0000%	23,652,426	0.2315%	0	0.0000%
33141	0	0.0000%	0	0.0000%	12,351,953	0.1209%	0	0.0000%
33142	0	0.0000%	0	0.0000%	6,447,894	0.0631%	0	0.0000%
33143	0	0.0000%	0	0.0000%	57,042,100	0.5582%	0	0.0000%
33144	0	0.0000%	0	0.0000%	9,101,744	0.0891%	0	0.0000%
33145	0	0.0000%	0	0.0000%	18,517,651	0.1812%	0	0.0000%
33146	0	0.0000%	0	0.0000%	28,432,179	0.2782%	0	0.0000%
33147	0	0.0000%	0	0.0000%	5,117,724	0.0501%	0	0.0000%
33149	0	0.0000%	0	0.0000%	32,080,120	0.3139%	0	0.0000%
33150	0	0.0000%	0	0.0000%	3,428,573	0.0336%	0	0.0000%
33154	0	0.0000%	0	0.0000%	12,211,099	0.1195%	0	0.0000%
33155	0	0.0000%	0	0.0000%	31,344,822	0.3067%	0	0.0000%
33156	0	0.0000%	0	0.0000%	107,877,437	1.0557%	0	0.0000%
33157	0	0.0000%	0	0.0000%	112,912,188	1.1049%	0	0.0000%
33158	0	0.0000%	0	0.0000%	28,013,116	0.2741%	0	0.0000%
33160	0	0.0000%	0	0.0000%	13,611,382	0.1332%	0	0.0000%
33161	0	0.0000%	0	0.0000%	9,227,459	0.0903%	0	0.0000%
33162	0	0.0000%	0	0.0000%	8,184,990	0.0801%	0	0.0000%
33165	0	0.0000%	0	0.0000%	25,759,505	0.2521%	0	0.0000%
33166	0	0.0000%	0	0.0000%	5,560,096	0.0544%	0	0.0000%
33167	0	0.0000%	0	0.0000%	2,552,903	0.0250%	0	0.0000%
33168	0	0.0000%	0	0.0000%	4,289,213	0.0420%	0	0.0000%
33169	0	0.0000%	0	0.0000%	5,093,485	0.0498%	0	0.0000%
33170	0	0.0000%	0	0.0000%	7,999,523	0.0783%	0	0.0000%
33172	0	0.0000%	0	0.0000%	7,050,751	0.0690%	0	0.0000%
33173	0	0.0000%	0	0.0000%	25,901,980	0.2535%	0	0.0000%
33174	0	0.0000%	0	0.0000%	8,704,188	0.0852%	0	0.0000%
33175	0	0.0000%	0	0.0000%	28,705,984	0.2809%	0	0.0000%
33176	0	0.0000%	0	0.0000%	65,827,471	0.6442%	0	0.0000%
33177	0	0.0000%	0	0.0000%	33,838,173	0.3311%	0	0.0000%
33178	0	0.0000%	0	0.0000%	10,651,871	0.1042%	0	0.0000%
33179	0	0.0000%	0	0.0000%	8,854,462	0.0866%	0	0.0000%
33180	0	0.0000%	0	0.0000%	11,527,947	0.1128%	0	0.0000%
33181	0	0.0000%	0	0.0000%	4,901,818	0.0480%	0	0.0000%
33182	0	0.0000%	0	0.0000%	5,861,671	0.0574%	0	0.0000%
33183	0	0.0000%	0	0.0000%	21,542,839	0.2108%	0	0.0000%
33184	0	0.0000%	0	0.0000%	8,930,462	0.0874%	0	0.0000%
33185	0	0.0000%	0	0.0000%	13,722,591	0.1343%	0	0.0000%
33186	0	0.0000%	0	0.0000%	51,222,237	0.5012%	0	0.0000%
33187	0	0.0000%	0	0.0000%	15,155,743	0.1483%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
33189	0	0.0000%	0	0.0000%	38,580,668	0.3775%	0	0.0000%
33190	0	0.0000%	0	0.0000%	11,348,171	0.1111%	0	0.0000%
33193	0	0.0000%	0	0.0000%	21,905,539	0.2144%	0	0.0000%
33194	0	0.0000%	0	0.0000%	1,534,284	0.0150%	0	0.0000%
33196	0	0.0000%	0	0.0000%	28,511,949	0.2790%	0	0.0000%
33301	0	0.0000%	0	0.0000%	6,046,927	0.0592%	0	0.0000%
33304	0	0.0000%	0	0.0000%	5,051,976	0.0494%	0	0.0000%
33305	0	0.0000%	0	0.0000%	4,418,083	0.0432%	0	0.0000%
33306	0	0.0000%	0	0.0000%	1,575,286	0.0154%	0	0.0000%
33308	0	0.0000%	0	0.0000%	10,917,019	0.1068%	0	0.0000%
33309	0	0.0000%	0	0.0000%	3,479,540	0.0340%	0	0.0000%
33311	0	0.0000%	0	0.0000%	4,409,777	0.0432%	0	0.0000%
33312	0	0.0000%	0	0.0000%	7,812,653	0.0765%	0	0.0000%
33313	0	0.0000%	0	0.0000%	3,431,872	0.0336%	0	0.0000%
33314	0	0.0000%	0	0.0000%	1,979,569	0.0194%	0	0.0000%
33315	0	0.0000%	0	0.0000%	3,297,278	0.0323%	0	0.0000%
33316	0	0.0000%	0	0.0000%	6,226,070	0.0609%	0	0.0000%
33317	0	0.0000%	0	0.0000%	5,580,651	0.0546%	0	0.0000%
33319	0	0.0000%	0	0.0000%	3,936,658	0.0385%	0	0.0000%
33321	0	0.0000%	0	0.0000%	5,280,921	0.0517%	0	0.0000%
33322	0	0.0000%	0	0.0000%	6,065,081	0.0594%	0	0.0000%
33323	0	0.0000%	0	0.0000%	4,161,055	0.0407%	0	0.0000%
33324	0	0.0000%	0	0.0000%	7,744,319	0.0758%	0	0.0000%
33325	0	0.0000%	0	0.0000%	6,840,086	0.0669%	0	0.0000%
33326	0	0.0000%	0	0.0000%	10,203,165	0.0998%	0	0.0000%
33327	0	0.0000%	0	0.0000%	6,174,039	0.0604%	0	0.0000%
33328	0	0.0000%	0	0.0000%	6,292,607	0.0616%	0	0.0000%
33330	0	0.0000%	0	0.0000%	5,180,657	0.0507%	0	0.0000%
33331	0	0.0000%	0	0.0000%	8,876,975	0.0869%	0	0.0000%
33332	0	0.0000%	0	0.0000%	4,724,228	0.0462%	0	0.0000%
33334	0	0.0000%	0	0.0000%	5,851,011	0.0573%	0	0.0000%
33351	0	0.0000%	0	0.0000%	3,602,414	0.0353%	0	0.0000%
33401	0	0.0000%	116,327	0.0172%	722,961	0.0071%	0	0.0000%
33404	0	0.0000%	297,345	0.0440%	762,827	0.0075%	0	0.0000%
33405	0	0.0000%	0	0.0000%	1,110,632	0.0109%	0	0.0000%
33406	0	0.0000%	0	0.0000%	718,894	0.0070%	0	0.0000%
33407	0	0.0000%	157,049	0.0233%	533,341	0.0052%	0	0.0000%
33408	0	0.0000%	802,279	0.1188%	1,501,666	0.0147%	0	0.0000%
33409	0	0.0000%	117,896	0.0175%	454,541	0.0044%	0	0.0000%
33410	0	0.0000%	1,074,940	0.1592%	1,379,859	0.0135%	0	0.0000%
33411	0	0.0000%	0	0.0000%	2,126,985	0.0208%	0	0.0000%
33412	0	0.0000%	122,665	0.0182%	795,081	0.0078%	0	0.0000%
33414	0	0.0000%	0	0.0000%	3,471,626	0.0340%	0	0.0000%
33415	0	0.0000%	0	0.0000%	743,692	0.0073%	0	0.0000%
33417	0	0.0000%	100,342	0.0149%	521,598	0.0051%	0	0.0000%
33418	0	0.0000%	1,438,728	0.2131%	2,112,699	0.0207%	0	0.0000%
33426	0	0.0000%	0	0.0000%	1,744,790	0.0171%	0	0.0000%
33428	0	0.0000%	0	0.0000%	3,023,784	0.0296%	0	0.0000%
33430	0	0.0000%	0	0.0000%	1,263,972	0.0124%	0	0.0000%
33431	0	0.0000%	0	0.0000%	3,654,185	0.0358%	0	0.0000%
33432	0	0.0000%	0	0.0000%	6,482,147	0.0634%	0	0.0000%
33433	0	0.0000%	0	0.0000%	4,963,786	0.0486%	0	0.0000%
33434	0	0.0000%	0	0.0000%	2,279,181	0.0223%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
33435	0	0.0000%	0	0.0000%	3,331,649	0.0326%	0	0.0000%
33436	0	0.0000%	0	0.0000%	3,688,094	0.0361%	0	0.0000%
33437	0	0.0000%	0	0.0000%	2,348,515	0.0230%	0	0.0000%
33440	0	0.0000%	0	0.0000%	16,711,012	0.1635%	0	0.0000%
33441	0	0.0000%	0	0.0000%	4,151,272	0.0406%	0	0.0000%
33442	0	0.0000%	0	0.0000%	3,087,915	0.0302%	0	0.0000%
33444	0	0.0000%	0	0.0000%	2,163,604	0.0212%	0	0.0000%
33445	0	0.0000%	0	0.0000%	3,799,988	0.0372%	0	0.0000%
33446	0	0.0000%	0	0.0000%	2,155,141	0.0211%	0	0.0000%
33449	0	0.0000%	0	0.0000%	608,494	0.0060%	0	0.0000%
33455	0	0.0000%	3,356,641	0.4972%	1,353,634	0.0132%	0	0.0000%
33458	0	0.0000%	2,214,187	0.3280%	1,536,992	0.0150%	0	0.0000%
33460	0	0.0000%	0	0.0000%	1,407,497	0.0138%	0	0.0000%
33461	0	0.0000%	0	0.0000%	839,962	0.0082%	0	0.0000%
33462	0	0.0000%	0	0.0000%	2,460,783	0.0241%	0	0.0000%
33463	0	0.0000%	0	0.0000%	1,268,608	0.0124%	0	0.0000%
33467	0	0.0000%	0	0.0000%	2,055,049	0.0201%	0	0.0000%
33469	0	0.0000%	1,508,136	0.2234%	845,370	0.0083%	0	0.0000%
33470	0	0.0000%	0	0.0000%	1,391,792	0.0136%	0	0.0000%
33471	0	0.0000%	0	0.0000%	13,638,180	0.1335%	0	0.0000%
33472	0	0.0000%	0	0.0000%	877,573	0.0086%	0	0.0000%
33473	0	0.0000%	0	0.0000%	502,669	0.0049%	0	0.0000%
33477	0	0.0000%	1,454,801	0.2155%	1,210,124	0.0118%	0	0.0000%
33478	0	0.0000%	448,775	0.0665%	746,082	0.0073%	0	0.0000%
33480	0	0.0000%	0	0.0000%	6,850,466	0.0670%	0	0.0000%
33483	0	0.0000%	0	0.0000%	3,948,901	0.0386%	0	0.0000%
33484	0	0.0000%	0	0.0000%	2,176,118	0.0213%	0	0.0000%
33486	0	0.0000%	0	0.0000%	4,638,858	0.0454%	0	0.0000%
33487	0	0.0000%	0	0.0000%	4,855,894	0.0475%	0	0.0000%
33496	0	0.0000%	0	0.0000%	3,607,309	0.0353%	0	0.0000%
33498	0	0.0000%	0	0.0000%	1,776,006	0.0174%	0	0.0000%
33510	0	0.0000%	0	0.0000%	11,980,528	0.1172%	0	0.0000%
33511	0	0.0000%	0	0.0000%	23,536,109	0.2303%	0	0.0000%
33513	0	0.0000%	0	0.0000%	8,108,008	0.0793%	0	0.0000%
33514	0	0.0000%	0	0.0000%	1,066,487	0.0104%	0	0.0000%
33523	0	0.0000%	0	0.0000%	9,180,112	0.0898%	0	0.0000%
33525	0	0.0000%	0	0.0000%	13,392,209	0.1311%	0	0.0000%
33527	0	0.0000%	0	0.0000%	6,044,639	0.0592%	0	0.0000%
33534	0	0.0000%	0	0.0000%	4,080,805	0.0399%	0	0.0000%
33538	0	0.0000%	0	0.0000%	3,826,682	0.0374%	0	0.0000%
33540	0	0.0000%	0	0.0000%	9,220,480	0.0902%	0	0.0000%
33541	0	0.0000%	0	0.0000%	18,448,665	0.1805%	0	0.0000%
33542	0	0.0000%	0	0.0000%	22,245,062	0.2177%	0	0.0000%
33543	0	0.0000%	0	0.0000%	15,728,703	0.1539%	0	0.0000%
33544	0	0.0000%	0	0.0000%	11,081,753	0.1084%	0	0.0000%
33545	0	0.0000%	0	0.0000%	5,960,109	0.0583%	0	0.0000%
33547	0	0.0000%	0	0.0000%	14,999,473	0.1468%	0	0.0000%
33548	0	0.0000%	0	0.0000%	4,248,263	0.0416%	0	0.0000%
33549	0	0.0000%	0	0.0000%	8,559,781	0.0838%	0	0.0000%
33556	0	0.0000%	0	0.0000%	10,099,889	0.0988%	0	0.0000%
33558	0	0.0000%	0	0.0000%	9,154,337	0.0896%	0	0.0000%
33559	0	0.0000%	0	0.0000%	5,916,948	0.0579%	0	0.0000%
33563	0	0.0000%	0	0.0000%	9,037,836	0.0884%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
33565	0	0.0000%	0	0.0000%	12,454,671	0.1219%	0	0.0000%
33566	0	0.0000%	0	0.0000%	11,700,102	0.1145%	0	0.0000%
33567	0	0.0000%	0	0.0000%	5,000,514	0.0489%	0	0.0000%
33569	0	0.0000%	0	0.0000%	15,665,075	0.1533%	0	0.0000%
33570	0	0.0000%	0	0.0000%	19,266,828	0.1885%	0	0.0000%
33572	0	0.0000%	0	0.0000%	19,493,344	0.1908%	0	0.0000%
33573	0	0.0000%	0	0.0000%	19,811,995	0.1939%	0	0.0000%
33576	0	0.0000%	0	0.0000%	2,614,243	0.0256%	0	0.0000%
33578	0	0.0000%	0	0.0000%	16,529,466	0.1618%	0	0.0000%
33579	0	0.0000%	0	0.0000%	10,275,906	0.1006%	0	0.0000%
33584	0	0.0000%	0	0.0000%	10,775,368	0.1054%	0	0.0000%
33585	0	0.0000%	0	0.0000%	1,087,454	0.0106%	0	0.0000%
33592	0	0.0000%	0	0.0000%	4,592,659	0.0449%	0	0.0000%
33594	0	0.0000%	0	0.0000%	19,086,486	0.1868%	0	0.0000%
33596	0	0.0000%	0	0.0000%	22,102,331	0.2163%	0	0.0000%
33597	0	0.0000%	0	0.0000%	5,115,588	0.0501%	0	0.0000%
33598	0	0.0000%	0	0.0000%	5,650,502	0.0553%	0	0.0000%
33602	0	0.0000%	0	0.0000%	4,766,295	0.0466%	0	0.0000%
33603	0	0.0000%	0	0.0000%	5,633,165	0.0551%	0	0.0000%
33604	0	0.0000%	0	0.0000%	8,609,269	0.0842%	0	0.0000%
33605	0	0.0000%	0	0.0000%	2,456,508	0.0240%	0	0.0000%
33606	0	0.0000%	0	0.0000%	10,703,139	0.1047%	0	0.0000%
33607	0	0.0000%	0	0.0000%	4,408,983	0.0431%	0	0.0000%
33609	0	0.0000%	0	0.0000%	10,652,323	0.1042%	0	0.0000%
33610	0	0.0000%	0	0.0000%	6,352,500	0.0622%	0	0.0000%
33611	0	0.0000%	0	0.0000%	16,710,489	0.1635%	0	0.0000%
33612	0	0.0000%	0	0.0000%	7,981,065	0.0781%	0	0.0000%
33613	0	0.0000%	0	0.0000%	9,030,128	0.0884%	0	0.0000%
33614	0	0.0000%	0	0.0000%	7,048,643	0.0690%	0	0.0000%
33615	0	0.0000%	0	0.0000%	8,512,854	0.0833%	0	0.0000%
33616	0	0.0000%	0	0.0000%	5,121,608	0.0501%	0	0.0000%
33617	0	0.0000%	0	0.0000%	11,679,932	0.1143%	0	0.0000%
33618	0	0.0000%	0	0.0000%	12,990,719	0.1271%	0	0.0000%
33619	0	0.0000%	0	0.0000%	6,644,587	0.0650%	0	0.0000%
33624	0	0.0000%	0	0.0000%	14,302,298	0.1400%	0	0.0000%
33625	0	0.0000%	0	0.0000%	6,396,391	0.0626%	0	0.0000%
33626	0	0.0000%	0	0.0000%	7,039,333	0.0689%	0	0.0000%
33629	0	0.0000%	0	0.0000%	22,139,563	0.2167%	0	0.0000%
33634	0	0.0000%	0	0.0000%	4,409,358	0.0431%	0	0.0000%
33635	0	0.0000%	0	0.0000%	3,056,293	0.0299%	0	0.0000%
33637	0	0.0000%	0	0.0000%	3,550,718	0.0347%	0	0.0000%
33647	0	0.0000%	0	0.0000%	30,208,116	0.2956%	0	0.0000%
33701	0	0.0000%	0	0.0000%	2,841,591	0.0278%	0	0.0000%
33702	0	0.0000%	0	0.0000%	11,440,562	0.1120%	0	0.0000%
33703	0	0.0000%	0	0.0000%	11,713,798	0.1146%	0	0.0000%
33704	0	0.0000%	0	0.0000%	7,790,757	0.0762%	0	0.0000%
33705	0	0.0000%	0	0.0000%	5,319,660	0.0521%	0	0.0000%
33706	0	0.0000%	0	0.0000%	6,085,370	0.0595%	0	0.0000%
33707	0	0.0000%	0	0.0000%	5,243,970	0.0513%	0	0.0000%
33708	0	0.0000%	0	0.0000%	4,366,619	0.0427%	0	0.0000%
33709	0	0.0000%	0	0.0000%	2,969,050	0.0291%	0	0.0000%
33710	0	0.0000%	0	0.0000%	5,369,329	0.0525%	0	0.0000%
33711	0	0.0000%	0	0.0000%	2,589,270	0.0253%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
33712	0	0.0000%	0	0.0000%	3,209,817	0.0314%	0	0.0000%
33713	0	0.0000%	0	0.0000%	4,526,663	0.0443%	0	0.0000%
33714	0	0.0000%	0	0.0000%	2,201,607	0.0215%	0	0.0000%
33715	0	0.0000%	0	0.0000%	4,609,213	0.0451%	0	0.0000%
33716	0	0.0000%	0	0.0000%	2,088,492	0.0204%	0	0.0000%
33755	0	0.0000%	0	0.0000%	5,467,110	0.0535%	0	0.0000%
33756	0	0.0000%	0	0.0000%	8,450,779	0.0827%	0	0.0000%
33759	0	0.0000%	0	0.0000%	2,730,592	0.0267%	0	0.0000%
33760	0	0.0000%	0	0.0000%	1,935,878	0.0189%	0	0.0000%
33761	0	0.0000%	0	0.0000%	5,791,877	0.0567%	0	0.0000%
33762	0	0.0000%	0	0.0000%	2,760,624	0.0270%	0	0.0000%
33763	0	0.0000%	0	0.0000%	3,382,993	0.0331%	0	0.0000%
33764	0	0.0000%	0	0.0000%	5,469,197	0.0535%	0	0.0000%
33765	0	0.0000%	0	0.0000%	2,102,507	0.0206%	0	0.0000%
33767	0	0.0000%	0	0.0000%	4,794,215	0.0469%	0	0.0000%
33770	0	0.0000%	0	0.0000%	7,416,722	0.0726%	0	0.0000%
33771	0	0.0000%	0	0.0000%	5,320,270	0.0521%	0	0.0000%
33772	0	0.0000%	0	0.0000%	5,732,455	0.0561%	0	0.0000%
33773	0	0.0000%	0	0.0000%	3,003,824	0.0294%	0	0.0000%
33774	0	0.0000%	0	0.0000%	7,098,414	0.0695%	0	0.0000%
33776	0	0.0000%	0	0.0000%	5,498,528	0.0538%	0	0.0000%
33777	0	0.0000%	0	0.0000%	3,085,879	0.0302%	0	0.0000%
33778	0	0.0000%	0	0.0000%	4,128,382	0.0404%	0	0.0000%
33781	0	0.0000%	0	0.0000%	2,971,362	0.0291%	0	0.0000%
33782	0	0.0000%	0	0.0000%	4,490,644	0.0439%	0	0.0000%
33785	0	0.0000%	0	0.0000%	3,557,255	0.0348%	0	0.0000%
33786	0	0.0000%	0	0.0000%	1,547,721	0.0151%	0	0.0000%
33801	0	0.0000%	0	0.0000%	28,300,568	0.2769%	0	0.0000%
33803	0	0.0000%	0	0.0000%	36,510,221	0.3573%	0	0.0000%
33805	0	0.0000%	0	0.0000%	14,280,275	0.1397%	0	0.0000%
33809	0	0.0000%	0	0.0000%	30,568,311	0.2991%	0	0.0000%
33810	0	0.0000%	0	0.0000%	48,580,109	0.4754%	0	0.0000%
33811	0	0.0000%	0	0.0000%	19,566,556	0.1915%	0	0.0000%
33812	0	0.0000%	0	0.0000%	15,400,177	0.1507%	0	0.0000%
33813	0	0.0000%	0	0.0000%	53,029,065	0.5189%	0	0.0000%
33815	0	0.0000%	0	0.0000%	6,048,113	0.0592%	0	0.0000%
33823	0	0.0000%	0	0.0000%	39,581,048	0.3873%	0	0.0000%
33825	0	0.0000%	0	0.0000%	42,246,022	0.4134%	0	0.0000%
33827	0	0.0000%	0	0.0000%	5,647,078	0.0553%	0	0.0000%
33830	0	0.0000%	0	0.0000%	30,857,990	0.3020%	0	0.0000%
33834	0	0.0000%	0	0.0000%	3,162,949	0.0310%	0	0.0000%
33837	0	0.0000%	0	0.0000%	22,403,879	0.2192%	0	0.0000%
33838	0	0.0000%	0	0.0000%	4,082,686	0.0400%	0	0.0000%
33839	0	0.0000%	0	0.0000%	3,494,873	0.0342%	0	0.0000%
33841	0	0.0000%	0	0.0000%	9,188,109	0.0899%	0	0.0000%
33843	0	0.0000%	0	0.0000%	17,788,413	0.1741%	0	0.0000%
33844	0	0.0000%	0	0.0000%	43,695,371	0.4276%	0	0.0000%
33849	0	0.0000%	0	0.0000%	680,583	0.0067%	0	0.0000%
33850	0	0.0000%	0	0.0000%	12,206,240	0.1194%	0	0.0000%
33852	0	0.0000%	0	0.0000%	59,692,778	0.5841%	0	0.0000%
33853	0	0.0000%	0	0.0000%	13,641,210	0.1335%	0	0.0000%
33855	0	0.0000%	0	0.0000%	1,224,255	0.0120%	0	0.0000%
33857	0	0.0000%	0	0.0000%	3,000,734	0.0294%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
33859	0	0.0000%	0	0.0000%	19,953,260	0.1953%	0	0.0000%
33860	0	0.0000%	0	0.0000%	18,525,281	0.1813%	0	0.0000%
33865	0	0.0000%	0	0.0000%	602,414	0.0059%	0	0.0000%
33868	0	0.0000%	0	0.0000%	15,980,261	0.1564%	0	0.0000%
33870	0	0.0000%	0	0.0000%	38,844,634	0.3801%	0	0.0000%
33872	0	0.0000%	0	0.0000%	35,023,921	0.3427%	0	0.0000%
33873	0	0.0000%	0	0.0000%	10,418,097	0.1019%	0	0.0000%
33875	0	0.0000%	0	0.0000%	26,822,591	0.2625%	0	0.0000%
33876	0	0.0000%	0	0.0000%	21,720,764	0.2126%	0	0.0000%
33880	0	0.0000%	0	0.0000%	46,262,297	0.4527%	0	0.0000%
33881	0	0.0000%	0	0.0000%	53,445,806	0.5230%	0	0.0000%
33884	0	0.0000%	0	0.0000%	62,720,692	0.6138%	0	0.0000%
33890	0	0.0000%	0	0.0000%	5,099,306	0.0499%	0	0.0000%
33896	0	0.0000%	0	0.0000%	7,898,187	0.0773%	0	0.0000%
33897	0	0.0000%	0	0.0000%	17,123,656	0.1676%	0	0.0000%
33898	0	0.0000%	0	0.0000%	26,949,708	0.2637%	0	0.0000%
33901	0	0.0000%	0	0.0000%	17,768,590	0.1739%	0	0.0000%
33903	0	0.0000%	0	0.0000%	39,908,563	0.3905%	0	0.0000%
33904	0	0.0000%	0	0.0000%	64,528,743	0.6315%	0	0.0000%
33905	0	0.0000%	0	0.0000%	30,846,831	0.3019%	0	0.0000%
33907	0	0.0000%	0	0.0000%	24,049,302	0.2353%	0	0.0000%
33908	0	0.0000%	0	0.0000%	101,365,532	0.9919%	0	0.0000%
33909	0	0.0000%	0	0.0000%	18,370,545	0.1798%	0	0.0000%
33912	0	0.0000%	0	0.0000%	50,679,377	0.4959%	0	0.0000%
33913	0	0.0000%	0	0.0000%	39,041,153	0.3820%	0	0.0000%
33914	0	0.0000%	0	0.0000%	73,153,090	0.7159%	0	0.0000%
33916	0	0.0000%	0	0.0000%	7,704,273	0.0754%	0	0.0000%
33917	0	0.0000%	0	0.0000%	44,681,950	0.4372%	0	0.0000%
33919	0	0.0000%	0	0.0000%	62,537,182	0.6120%	0	0.0000%
33920	0	0.0000%	0	0.0000%	9,785,941	0.0958%	0	0.0000%
33921	0	0.0000%	0	0.0000%	22,868,372	0.2238%	0	0.0000%
33922	0	0.0000%	0	0.0000%	14,027,532	0.1373%	0	0.0000%
33924	0	0.0000%	0	0.0000%	15,589,599	0.1526%	0	0.0000%
33928	0	0.0000%	0	0.0000%	75,530,257	0.7391%	0	0.0000%
33931	0	0.0000%	0	0.0000%	42,515,113	0.4160%	0	0.0000%
33935	0	0.0000%	0	0.0000%	27,197,294	0.2661%	0	0.0000%
33936	0	0.0000%	0	0.0000%	33,491,877	0.3277%	0	0.0000%
33946	0	0.0000%	0	0.0000%	8,629,507	0.0844%	0	0.0000%
33947	0	0.0000%	0	0.0000%	11,047,261	0.1081%	0	0.0000%
33948	0	0.0000%	0	0.0000%	15,090,903	0.1477%	0	0.0000%
33950	0	0.0000%	0	0.0000%	50,746,007	0.4966%	0	0.0000%
33952	0	0.0000%	0	0.0000%	25,441,341	0.2490%	0	0.0000%
33953	0	0.0000%	0	0.0000%	6,030,530	0.0590%	0	0.0000%
33954	0	0.0000%	0	0.0000%	8,179,873	0.0800%	0	0.0000%
33955	0	0.0000%	0	0.0000%	22,311,722	0.2183%	0	0.0000%
33956	0	0.0000%	0	0.0000%	18,177,493	0.1779%	0	0.0000%
33957	0	0.0000%	0	0.0000%	82,547,259	0.8078%	0	0.0000%
33960	0	0.0000%	0	0.0000%	1,488,358	0.0146%	0	0.0000%
33966	0	0.0000%	0	0.0000%	14,977,700	0.1466%	0	0.0000%
33967	0	0.0000%	0	0.0000%	40,238,270	0.3938%	0	0.0000%
33971	0	0.0000%	0	0.0000%	18,157,910	0.1777%	0	0.0000%
33972	0	0.0000%	0	0.0000%	15,417,488	0.1509%	0	0.0000%
33973	0	0.0000%	0	0.0000%	4,767,708	0.0467%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
33974	0	0.0000%	0	0.0000%	14,342,167	0.1403%	0	0.0000%
33976	0	0.0000%	0	0.0000%	8,761,906	0.0857%	0	0.0000%
33980	0	0.0000%	0	0.0000%	13,826,671	0.1353%	0	0.0000%
33981	0	0.0000%	0	0.0000%	10,967,764	0.1073%	0	0.0000%
33982	0	0.0000%	0	0.0000%	11,905,500	0.1165%	0	0.0000%
33983	0	0.0000%	0	0.0000%	16,456,967	0.1610%	0	0.0000%
33990	0	0.0000%	0	0.0000%	35,068,438	0.3432%	0	0.0000%
33991	0	0.0000%	0	0.0000%	24,154,167	0.2364%	0	0.0000%
33993	0	0.0000%	0	0.0000%	22,766,613	0.2228%	0	0.0000%
34102	0	0.0000%	0	0.0000%	168,961,967	1.6534%	0	0.0000%
34103	0	0.0000%	0	0.0000%	123,680,372	1.2103%	0	0.0000%
34104	0	0.0000%	0	0.0000%	89,736,572	0.8781%	0	0.0000%
34105	0	0.0000%	0	0.0000%	125,234,947	1.2255%	0	0.0000%
34108	0	0.0000%	0	0.0000%	198,643,039	1.9439%	0	0.0000%
34109	0	0.0000%	0	0.0000%	120,404,442	1.1782%	0	0.0000%
34110	0	0.0000%	0	0.0000%	161,818,538	1.5835%	0	0.0000%
34112	0	0.0000%	0	0.0000%	138,990,432	1.3601%	0	0.0000%
34113	0	0.0000%	0	0.0000%	88,237,613	0.8635%	0	0.0000%
34114	0	0.0000%	0	0.0000%	56,326,663	0.5512%	0	0.0000%
34116	0	0.0000%	0	0.0000%	52,581,949	0.5146%	0	0.0000%
34117	0	0.0000%	0	0.0000%	34,242,405	0.3351%	0	0.0000%
34119	0	0.0000%	0	0.0000%	115,410,534	1.1294%	0	0.0000%
34120	0	0.0000%	0	0.0000%	76,713,892	0.7507%	0	0.0000%
34134	0	0.0000%	0	0.0000%	152,054,892	1.4880%	0	0.0000%
34135	0	0.0000%	0	0.0000%	150,516,588	1.4729%	0	0.0000%
34138	0	0.0000%	0	0.0000%	1,296,894	0.0127%	0	0.0000%
34139	0	0.0000%	0	0.0000%	2,813,860	0.0275%	0	0.0000%
34140	0	0.0000%	0	0.0000%	1,615,941	0.0158%	0	0.0000%
34141	0	0.0000%	0	0.0000%	535,055	0.0052%	0	0.0000%
34142	0	0.0000%	0	0.0000%	14,176,047	0.1387%	0	0.0000%
34145	0	0.0000%	0	0.0000%	198,474,892	1.9422%	0	0.0000%
34201	0	0.0000%	0	0.0000%	3,736,125	0.0366%	0	0.0000%
34202	0	0.0000%	0	0.0000%	17,784,902	0.1740%	0	0.0000%
34203	0	0.0000%	0	0.0000%	12,294,798	0.1203%	0	0.0000%
34205	0	0.0000%	0	0.0000%	10,101,483	0.0989%	0	0.0000%
34207	0	0.0000%	0	0.0000%	7,825,229	0.0766%	0	0.0000%
34208	0	0.0000%	0	0.0000%	8,677,745	0.0849%	0	0.0000%
34209	0	0.0000%	0	0.0000%	29,658,483	0.2902%	0	0.0000%
34210	0	0.0000%	0	0.0000%	8,072,213	0.0790%	0	0.0000%
34211	0	0.0000%	0	0.0000%	5,027,430	0.0492%	0	0.0000%
34212	0	0.0000%	0	0.0000%	10,746,472	0.1052%	0	0.0000%
34215	0	0.0000%	0	0.0000%	823,841	0.0081%	0	0.0000%
34216	0	0.0000%	0	0.0000%	2,150,974	0.0210%	0	0.0000%
34217	0	0.0000%	0	0.0000%	8,449,145	0.0827%	0	0.0000%
34219	0	0.0000%	0	0.0000%	12,197,615	0.1194%	0	0.0000%
34221	0	0.0000%	0	0.0000%	23,546,352	0.2304%	0	0.0000%
34222	0	0.0000%	0	0.0000%	7,373,708	0.0722%	0	0.0000%
34223	0	0.0000%	0	0.0000%	22,981,114	0.2249%	0	0.0000%
34224	0	0.0000%	0	0.0000%	16,699,550	0.1634%	0	0.0000%
34228	0	0.0000%	0	0.0000%	8,372,745	0.0819%	0	0.0000%
34229	0	0.0000%	0	0.0000%	9,155,805	0.0896%	0	0.0000%
34231	0	0.0000%	0	0.0000%	22,309,703	0.2183%	0	0.0000%
34232	0	0.0000%	0	0.0000%	14,766,827	0.1445%	0	0.0000%
34233	0	0.0000%	0	0.0000%	9,822,060	0.0961%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
34234	0	0.0000%	0	0.0000%	5,232,861	0.0512%	0	0.0000%
34235	0	0.0000%	0	0.0000%	7,803,953	0.0764%	0	0.0000%
34236	0	0.0000%	0	0.0000%	7,093,340	0.0694%	0	0.0000%
34237	0	0.0000%	0	0.0000%	4,339,406	0.0425%	0	0.0000%
34238	0	0.0000%	0	0.0000%	15,066,215	0.1474%	0	0.0000%
34239	0	0.0000%	0	0.0000%	10,068,188	0.0985%	0	0.0000%
34240	0	0.0000%	0	0.0000%	10,381,818	0.1016%	0	0.0000%
34241	0	0.0000%	0	0.0000%	12,082,241	0.1182%	0	0.0000%
34242	0	0.0000%	0	0.0000%	12,780,820	0.1251%	0	0.0000%
34243	0	0.0000%	0	0.0000%	12,914,071	0.1264%	0	0.0000%
34251	0	0.0000%	0	0.0000%	4,125,413	0.0404%	0	0.0000%
34266	0	0.0000%	0	0.0000%	22,983,646	0.2249%	0	0.0000%
34269	0	0.0000%	0	0.0000%	5,784,277	0.0566%	0	0.0000%
34275	0	0.0000%	0	0.0000%	18,852,658	0.1845%	0	0.0000%
34285	0	0.0000%	0	0.0000%	21,442,165	0.2098%	0	0.0000%
34286	0	0.0000%	0	0.0000%	9,871,398	0.0966%	0	0.0000%
34287	0	0.0000%	0	0.0000%	21,092,246	0.2064%	0	0.0000%
34288	0	0.0000%	0	0.0000%	6,348,734	0.0621%	0	0.0000%
34289	0	0.0000%	0	0.0000%	1,295,563	0.0127%	0	0.0000%
34291	0	0.0000%	0	0.0000%	2,916,672	0.0285%	0	0.0000%
34292	0	0.0000%	0	0.0000%	11,958,914	0.1170%	0	0.0000%
34293	0	0.0000%	0	0.0000%	30,366,524	0.2972%	0	0.0000%
34420	0	0.0000%	0	0.0000%	9,116,173	0.0892%	0	0.0000%
34428	0	0.0000%	0	0.0000%	3,513,317	0.0344%	0	0.0000%
34429	0	0.0000%	0	0.0000%	5,600,331	0.0548%	0	0.0000%
34431	0	0.0000%	0	0.0000%	3,703,589	0.0362%	0	0.0000%
34432	0	0.0000%	0	0.0000%	7,367,038	0.0721%	0	0.0000%
34433	0	0.0000%	0	0.0000%	2,732,788	0.0267%	0	0.0000%
34434	0	0.0000%	0	0.0000%	3,041,779	0.0298%	0	0.0000%
34436	0	0.0000%	0	0.0000%	4,486,914	0.0439%	0	0.0000%
34442	0	0.0000%	0	0.0000%	9,077,637	0.0888%	0	0.0000%
34446	0	0.0000%	0	0.0000%	7,429,500	0.0727%	0	0.0000%
34448	0	0.0000%	0	0.0000%	5,175,807	0.0506%	0	0.0000%
34449	0	0.0000%	0	0.0000%	1,069,382	0.0105%	0	0.0000%
34450	0	0.0000%	0	0.0000%	6,171,422	0.0604%	0	0.0000%
34452	0	0.0000%	0	0.0000%	4,981,253	0.0487%	0	0.0000%
34453	0	0.0000%	0	0.0000%	4,319,534	0.0423%	0	0.0000%
34461	0	0.0000%	0	0.0000%	4,921,854	0.0482%	0	0.0000%
34465	0	0.0000%	0	0.0000%	7,694,494	0.0753%	0	0.0000%
34470	0	0.0000%	0	0.0000%	7,840,890	0.0767%	0	0.0000%
34471	0	0.0000%	0	0.0000%	17,388,179	0.1702%	0	0.0000%
34472	0	0.0000%	0	0.0000%	11,256,378	0.1102%	0	0.0000%
34473	0	0.0000%	0	0.0000%	9,417,333	0.0922%	0	0.0000%
34474	0	0.0000%	0	0.0000%	8,779,104	0.0859%	0	0.0000%
34475	0	0.0000%	0	0.0000%	3,595,356	0.0352%	0	0.0000%
34476	0	0.0000%	0	0.0000%	18,093,331	0.1771%	0	0.0000%
34479	0	0.0000%	0	0.0000%	5,454,579	0.0534%	0	0.0000%
34480	0	0.0000%	0	0.0000%	11,796,861	0.1154%	0	0.0000%
34481	0	0.0000%	0	0.0000%	12,796,758	0.1252%	0	0.0000%
34482	0	0.0000%	0	0.0000%	14,483,603	0.1417%	0	0.0000%
34484	0	0.0000%	0	0.0000%	2,851,181	0.0279%	0	0.0000%
34488	0	0.0000%	0	0.0000%	3,339,912	0.0327%	0	0.0000%
34491	0	0.0000%	0	0.0000%	20,161,353	0.1973%	0	0.0000%
34498	0	0.0000%	0	0.0000%	695,845	0.0068%	9,250	0.0002%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
34601	0	0.0000%	0	0.0000%	8,506,179	0.0832%	0	0.0000%
34602	0	0.0000%	0	0.0000%	3,723,079	0.0364%	0	0.0000%
34604	0	0.0000%	0	0.0000%	2,918,121	0.0286%	0	0.0000%
34606	0	0.0000%	0	0.0000%	14,887,487	0.1457%	0	0.0000%
34607	0	0.0000%	0	0.0000%	9,191,063	0.0899%	0	0.0000%
34608	0	0.0000%	0	0.0000%	9,862,136	0.0965%	0	0.0000%
34609	0	0.0000%	0	0.0000%	11,515,746	0.1127%	0	0.0000%
34610	0	0.0000%	0	0.0000%	4,164,743	0.0408%	0	0.0000%
34613	0	0.0000%	0	0.0000%	13,931,236	0.1363%	0	0.0000%
34614	0	0.0000%	0	0.0000%	2,354,787	0.0230%	0	0.0000%
34637	0	0.0000%	0	0.0000%	2,480,794	0.0243%	0	0.0000%
34638	0	0.0000%	0	0.0000%	6,969,444	0.0682%	0	0.0000%
34639	0	0.0000%	0	0.0000%	12,120,780	0.1186%	0	0.0000%
34652	0	0.0000%	0	0.0000%	10,757,974	0.1053%	0	0.0000%
34653	0	0.0000%	0	0.0000%	9,448,890	0.0925%	0	0.0000%
34654	0	0.0000%	0	0.0000%	5,587,231	0.0547%	0	0.0000%
34655	0	0.0000%	0	0.0000%	9,789,715	0.0958%	0	0.0000%
34667	0	0.0000%	0	0.0000%	21,863,274	0.2139%	0	0.0000%
34668	0	0.0000%	0	0.0000%	17,350,507	0.1698%	0	0.0000%
34669	0	0.0000%	0	0.0000%	3,787,657	0.0371%	0	0.0000%
34677	0	0.0000%	0	0.0000%	5,349,005	0.0523%	0	0.0000%
34681	0	0.0000%	0	0.0000%	861,879	0.0084%	0	0.0000%
34683	0	0.0000%	0	0.0000%	15,176,641	0.1485%	0	0.0000%
34684	0	0.0000%	0	0.0000%	8,511,089	0.0833%	0	0.0000%
34685	0	0.0000%	0	0.0000%	5,088,011	0.0498%	0	0.0000%
34688	0	0.0000%	0	0.0000%	2,964,701	0.0290%	0	0.0000%
34689	0	0.0000%	0	0.0000%	10,632,260	0.1040%	0	0.0000%
34690	0	0.0000%	0	0.0000%	3,602,229	0.0353%	0	0.0000%
34691	0	0.0000%	0	0.0000%	6,711,777	0.0657%	0	0.0000%
34695	0	0.0000%	0	0.0000%	4,564,115	0.0447%	0	0.0000%
34698	0	0.0000%	0	0.0000%	14,448,369	0.1414%	0	0.0000%
34705	0	0.0000%	15,126	0.0022%	2,259,642	0.0221%	0	0.0000%
34711	0	0.0000%	0	0.0000%	38,679,307	0.3785%	0	0.0000%
34714	0	0.0000%	0	0.0000%	9,663,506	0.0946%	0	0.0000%
34715	0	0.0000%	0	0.0000%	10,014,183	0.0980%	0	0.0000%
34731	0	0.0000%	0	0.0000%	9,931,140	0.0972%	0	0.0000%
34734	0	0.0000%	88,146	0.0131%	1,595,207	0.0156%	0	0.0000%
34736	0	0.0000%	0	0.0000%	11,184,884	0.1095%	0	0.0000%
34737	0	0.0000%	0	0.0000%	2,352,819	0.0230%	0	0.0000%
34739	0	0.0000%	0	0.0000%	658,278	0.0064%	0	0.0000%
34741	0	0.0000%	0	0.0000%	10,031,427	0.0982%	0	0.0000%
34743	0	0.0000%	0	0.0000%	11,843,891	0.1159%	0	0.0000%
34744	0	0.0000%	0	0.0000%	17,035,992	0.1667%	0	0.0000%
34746	0	0.0000%	0	0.0000%	28,482,945	0.2787%	0	0.0000%
34747	0	0.0000%	0	0.0000%	18,291,698	0.1790%	0	0.0000%
34748	0	0.0000%	0	0.0000%	36,586,603	0.3580%	0	0.0000%
34753	0	0.0000%	0	0.0000%	1,989,954	0.0195%	0	0.0000%
34756	0	0.0000%	0	0.0000%	2,943,334	0.0288%	0	0.0000%
34758	0	0.0000%	0	0.0000%	16,632,318	0.1628%	0	0.0000%
34759	0	0.0000%	0	0.0000%	17,296,213	0.1693%	0	0.0000%
34760	0	0.0000%	0	0.0000%	542,356	0.0053%	0	0.0000%
34761	0	0.0000%	998,803	0.1480%	10,693,001	0.1046%	0	0.0000%
34769	0	0.0000%	0	0.0000%	7,893,468	0.0772%	0	0.0000%
34771	0	0.0000%	111,375	0.0165%	5,667,537	0.0555%	0	0.0000%

Form A-3: Hurricane Losses

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

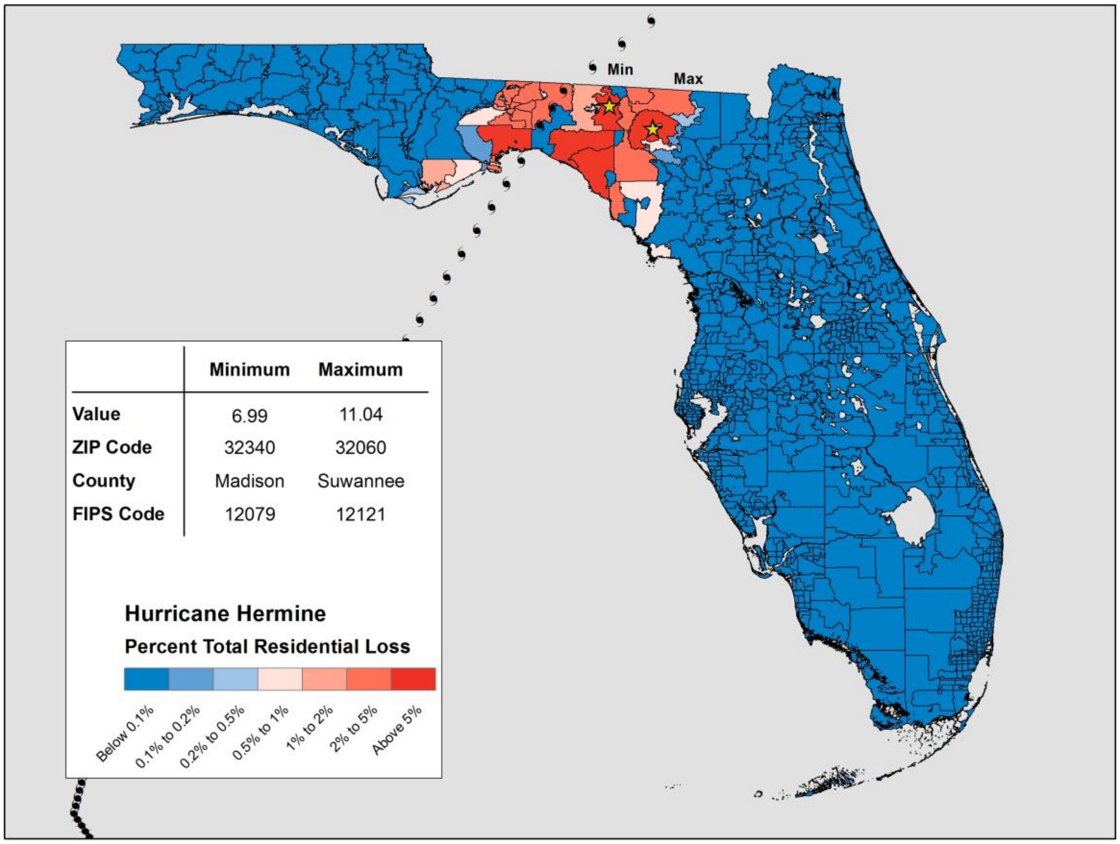
ZIP Code	Hurricane Hermine (2016)		Hurricane Matthew (2016)		Hurricane Irma (2017)		Hurricane Michael (2018)	
	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)	Personal & Commercial Residential Monetary Contribution ($)	Percent of Losses (%)
34772	0	0.0000%	0	0.0000%	9,359,494	0.0916%	0	0.0000%
34773	0	0.0000%	46,971	0.0070%	830,857	0.0081%	0	0.0000%
34785	0	0.0000%	0	0.0000%	12,338,800	0.1207%	0	0.0000%
34786	0	0.0000%	0	0.0000%	29,245,202	0.2862%	0	0.0000%
34787	0	0.0000%	0	0.0000%	26,118,813	0.2556%	0	0.0000%
34788	0	0.0000%	101,372	0.0150%	18,599,074	0.1820%	0	0.0000%
34797	0	0.0000%	0	0.0000%	1,209,337	0.0118%	0	0.0000%
34945	0	0.0000%	475,432	0.0704%	339,240	0.0033%	0	0.0000%
34946	0	0.0000%	567,704	0.0841%	224,575	0.0022%	0	0.0000%
34947	0	0.0000%	392,409	0.0581%	175,790	0.0017%	0	0.0000%
34949	0	0.0000%	2,318,805	0.3435%	897,214	0.0088%	0	0.0000%
34950	0	0.0000%	644,184	0.0954%	260,803	0.0026%	0	0.0000%
34951	0	0.0000%	2,042,217	0.3025%	1,009,577	0.0099%	0	0.0000%
34952	0	0.0000%	4,361,011	0.6460%	2,505,539	0.0245%	0	0.0000%
34953	0	0.0000%	2,678,607	0.3968%	3,196,299	0.0313%	0	0.0000%
34957	0	0.0000%	2,881,441	0.4268%	1,212,290	0.0119%	0	0.0000%
34972	0	0.0000%	0	0.0000%	4,633,890	0.0453%	0	0.0000%
34974	0	0.0000%	0	0.0000%	41,491,969	0.4060%	0	0.0000%
34982	0	0.0000%	2,120,250	0.3141%	963,532	0.0094%	0	0.0000%
34983	0	0.0000%	2,841,812	0.4210%	1,924,440	0.0188%	0	0.0000%
34984	0	0.0000%	1,014,822	0.1503%	866,273	0.0085%	0	0.0000%
34986	0	0.0000%	2,239,350	0.3317%	1,827,698	0.0179%	0	0.0000%
34987	0	0.0000%	416,077	0.0616%	682,403	0.0067%	0	0.0000%
34990	0	0.0000%	2,758,219	0.4086%	2,482,248	0.0243%	0	0.0000%
34994	0	0.0000%	1,047,278	0.1551%	560,539	0.0055%	0	0.0000%
34996	0	0.0000%	2,327,181	0.3447%	751,104	0.0074%	0	0.0000%
34997	0	0.0000%	3,568,019	0.5285%	2,049,093	0.0201%	0	0.0000%

C. Provide maps color-coded by ZIP Code depicting the percentage of total residential hurricane losses from each hurricane: Hurricane Hermine (2016), Hurricane Matthew (2016), Hurricane Irma (2017), and Hurricane Michael (2018) using the following interval coding.

Red	*Over 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 Below	*0.1%*

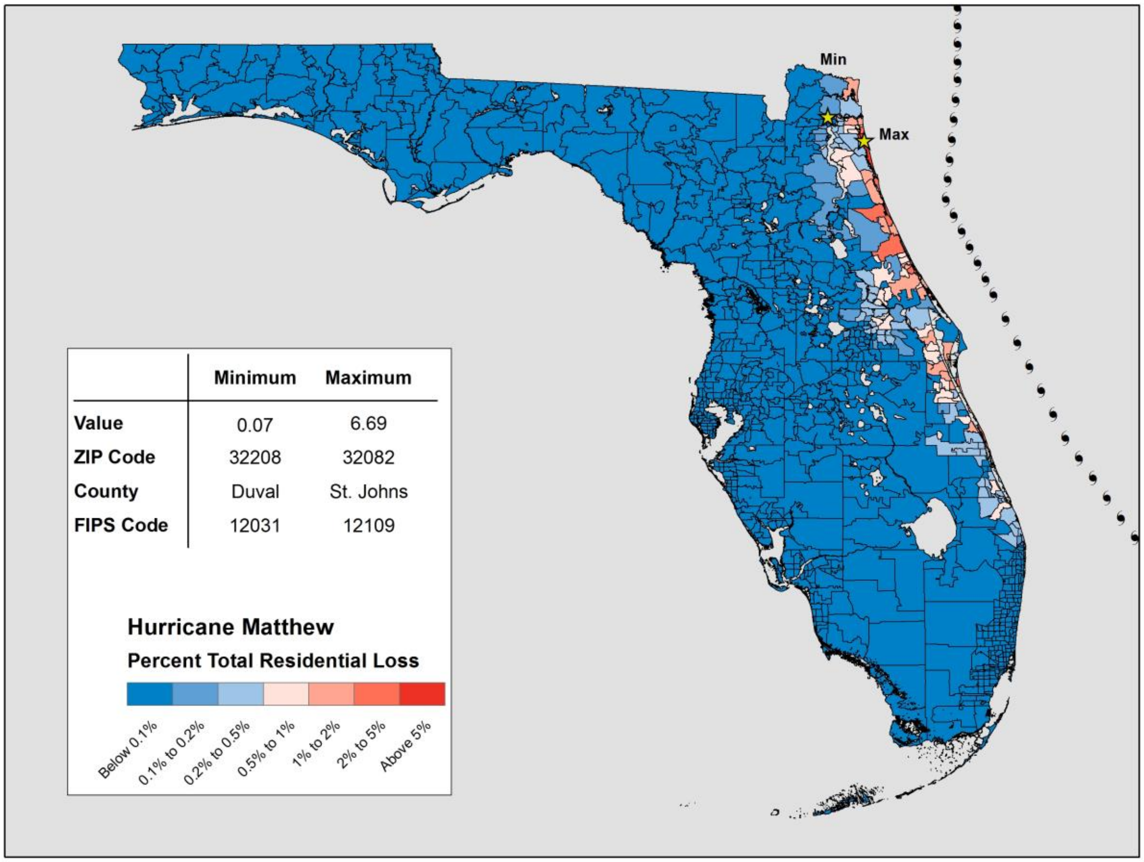
D. Plot the relevant storm track on each map.

The maps in Figure 67 to Figure 70 depict the percentage of gross, zero deductible losses from each specified event and in total for all events, using 2017 FHCF exposure data.



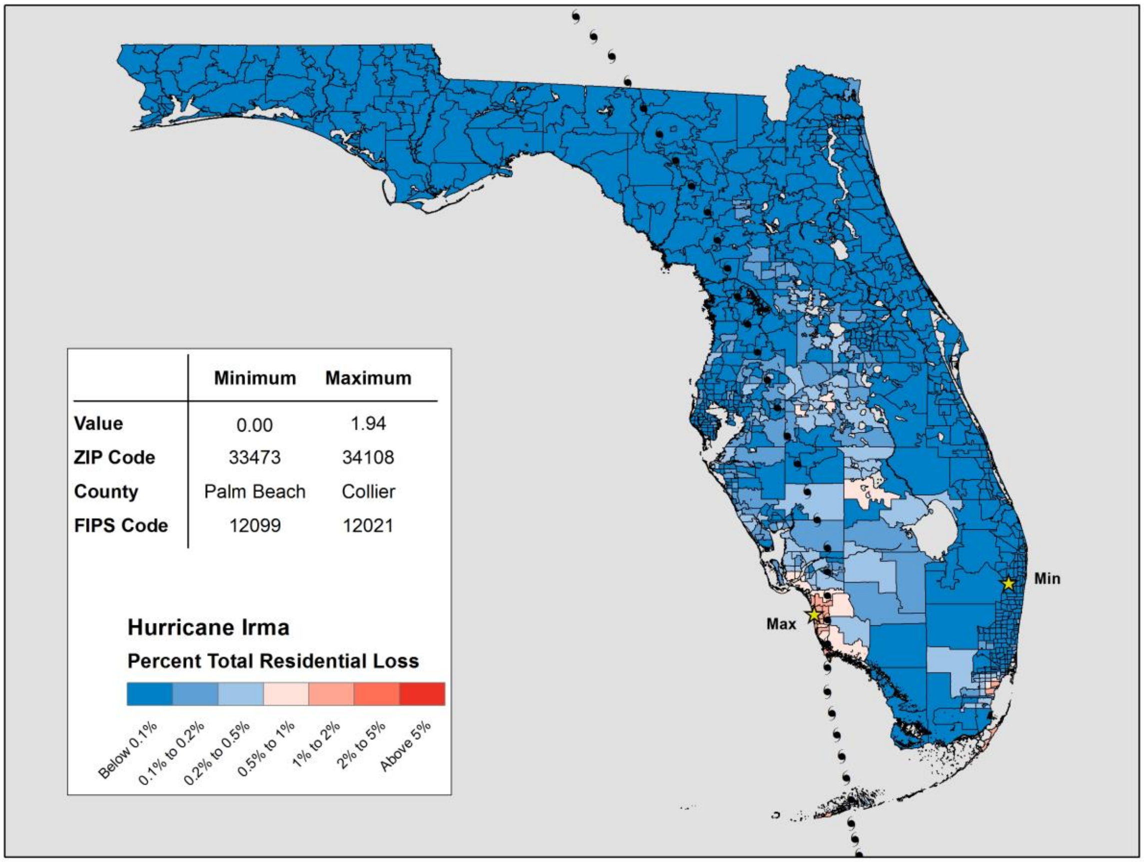
	Minimum	Maximum
Value	6.99	11.04
ZIP Code	32340	32060
County	Madison	Suwannee
FIPS Code	12079	12121

Figure 67. Percentage of Total Residential Loss from Hurricane Hermine (2016) Using 2017 FHCF Exposure Data



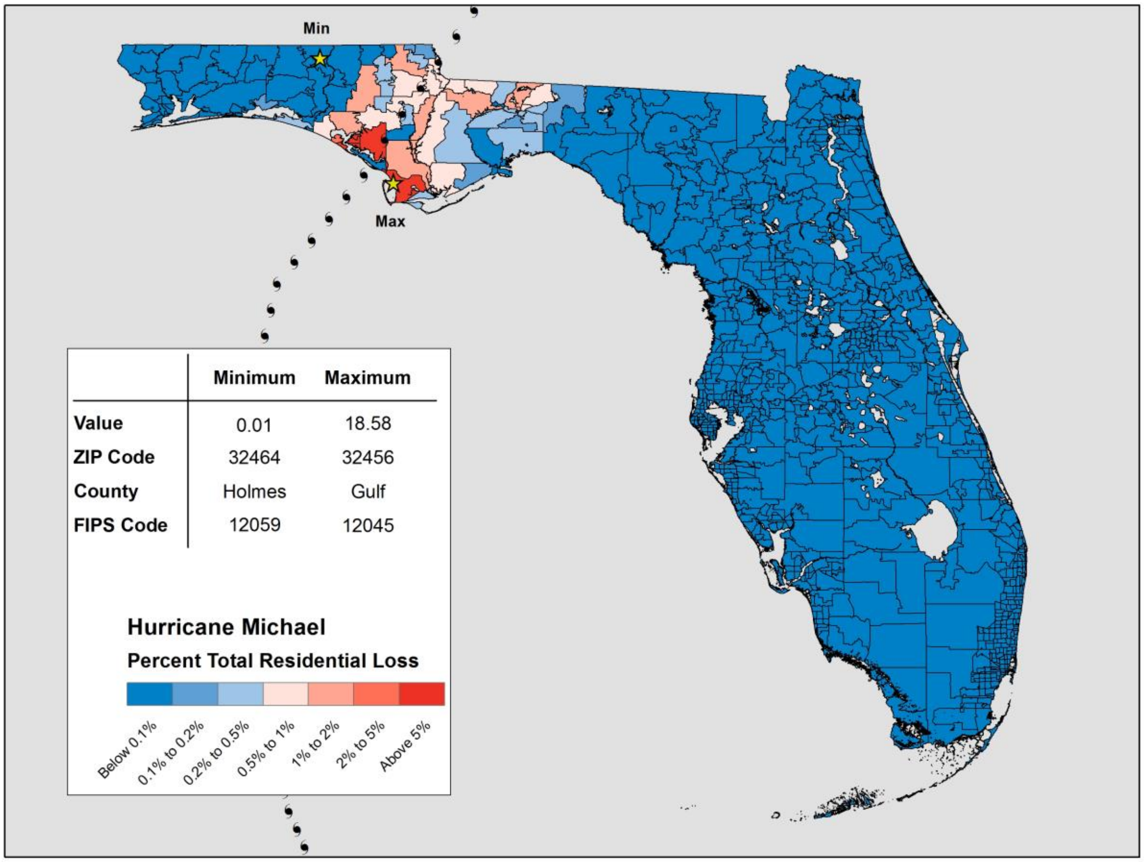
	Minimum	Maximum
Value	0.07	6.69
ZIP Code	32208	32082
County	Duval	St. Johns
FIPS Code	12031	12109

Figure 68. Percentage of Total Residential Loss from Hurricane Matthew (2016) Using 2017 FHCF Exposure Data



	Minimum	Maximum
Value	0.00	1.94
ZIP Code	33473	34108
County	Palm Beach	Collier
FIPS Code	12099	12021

Figure 69. Percentage of Total Residential Loss from Hurricane Irma (2017) Using 2017 FHCF Exposure Data



	Minimum	Maximum
Value	0.01	18.58
ZIP Code	32464	32456
County	Holmes	Gulf
FIPS Code	12059	12045

Figure 70. Percentage of Total Residential Loss from Hurricane Michael (2017) Using 2017 FHCF Exposure Data

E. ***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-3, Hurricane Losses in a submission appendix.***

A hard copy of Form A-3 is included in this submission appendix and is also provided in Excel.

Form A-4: Hurricane Output Ranges

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 "2019FormA4.xlsx."

Form A-4 was prepared using an automated process designed to limit the amount of manual intervention and decrease time and diligence. During the automation process, AIR exercised due diligence verifying that the process reproduced the same indications as Form A-4 in prior submissions.

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, Hurricane Output Ranges, in a submission appendix.

Form A-4 is provided in excel format.

C. Provide hurricane loss costs, rounded to three decimal places, by county. 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 range shall show the highest hurricane loss cost, the lowest hurricane loss cost, and the weighted average hurricane loss cost. The aggregate residential exposure data for this form shall be developed from the information in the file named "hlpm2017c.zip," except for insured values and deductibles information. Insured values shall be based on the hurricane output range specifications given below. Deductible amounts of 0% and as specified in the hurricane output range specifications given below shall 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).

Hurricane Output Range Specifications

Policy Type: Owners
Assumptions

Coverage A = Building
- *Coverage A limit = $100,000*
- *Replacement Cost included subject to Coverage A limit*
- *Law and Ordinance included*

Coverage B = Appurtenant Structure
- *Coverage B limit = 10% of Coverage A limit*
- *Replacement Cost included subject to Coverage B limit*
- *Law and Ordinance included*

Coverage C = Contents
- *Coverage C limit = 50% of Coverage A limit*

- *Replacement Cost included subject to Coverage C limit*

Coverage D = Time Element

- *Coverage D limit = 20% of Coverage A limit*
- *Time limit = 12 months*
- *Per diem = $150.00/day per policy, if used*

** Dominant Coverage = A*
** Hurricane loss costs per $1,000 shall be related to the Coverage A limit*
** Hurricane loss costs for the various specified deductibles shall be determined based on annual deductibles*
** 2% Deductible of Coverage A*
** All-other perils deductible = $500*

Policy Type: Renters
Assumptions

Coverage C = Contents

- *Coverage C limit = $50,000*
- *Replacement Cost included subject to Coverage C limit*

Coverage D = Time Element

- *Coverage D limit = 40% of Coverage C limit*
- *Time limit = 12 months*
- *Per diem = $150.00/day per policy, if used*

** Dominate Coverage = C*
** Hurricane loss costs per $1,000 shall be related to the Coverage C limit*
** Hurricane loss costs for the various specified deductibles shall be determined based on annual deductibles*
** 2% Deductible of Coverage C*
** All-other perils deductible = $500*

Policy Type: Condo Unit Owners
Assumptions

Coverage A = Building

- *Coverage A limit = 10% of Coverage C limit*
- *Replacement Cost included subject to Coverage A limit*

Coverage C = Contents

- *Coverage C limit = $50,000*
- *Replacement Cost included subject to Coverage C limit*

Coverage D = Time Element

- *Coverage D limit = 40% of Coverage C limit*
- *Time limit = 12 months*
- *Per diem = $150.00/day per policy, if used*

** Dominate Coverage = C*
** Hurricane loss costs per $1,000 shall be related to the Coverage C limit*
** Hurricane loss costs for the various specified deductibles shall be determined based on annual deductibles*
** 2% Deductible of Coverage C*
** All-other perils deductible = $500*

Policy Type: Manufactured Homes
Assumptions

Coverage A = Building

- *Coverage A limit = $50,000*
- *Replacement Cost included subject to Coverage A limit*

Coverage B = Appurtenant Structure

- *Coverage B limit = 10% of Coverage A limit*
- *Replacement Cost included subject to Coverage B limit*

Coverage C = Contents

- *Coverage C limit = 50% of Coverage A limit*
- *Replacement Cost included subject to Coverage C limit*

Coverage D = Time Element

- *Coverage D limit = 20% of Coverage A limit*
- *Time limit = 12 months*
- *Per diem = $150.00/day per policy, if used*

** Dominant Coverage = A*
** Hurricane loss costs per $1,000 shall be related to the Coverage A limit*
** Hurricane loss costs for the various specified deductibles shall be determined based on annual deductibles*
** 2% Deductible of Coverage A*
** All-other perils deductible = $500*

Policy Type: Commercial Residential
Assumptions

Coverage A = Building

- *Coverage A limit = $25,000,000*
- *Replacement Cost included subject to Coverage A limit*

Coverage C = Contents

- *Coverage C limit = 50% of Coverage A limit*
- *Replacement Cost included subject to Coverage C limit*

Coverage D = Time Element

- *Coverage D limit = 20% of Coverage A limit*
- *Time limit = 12 months*
- *Per diem = $150.00/day per policy, if used*

** Dominant Coverage = A*
** Hurricane loss costs per $1,000 shall be related to the Coverage A limit*
** Hurricane loss costs for the various specified deductibles shall be determined based on annual deductibles*
** 2% Deductible of Coverage A*
** All-other perils deductible = $5,000*

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 in the submission document of those ZIP Codes where this occurs.

A loss cost is not produced in any case where there is no exposure.

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 in the submission document of the ZIP Codes where this occurs.

There are no ZIP Codes in the FHCF data for which AIR does not produce loss costs. FHCF ZIP Codes are remapped to current ZIP Codes by AIR.

F. NA shall be used in cells to signify no exposure.

NA has been used in cells to signify no exposure.

G. All hurricane loss costs that are not consistent with the requirements of Standard A-6, Hurricane Loss Outputs and Logical Relationships to Risk, and have been explained in Disclosure A-6. 14 shall be shaded.

All such anomalies are shaded in orange below in Table 47.

H. 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 $150.00 per day per policy shall be used.

A $150 per diem per policy is used in producing loss costs for Coverage D.

Table 47. Output Ranges -- Loss Costs per $1000 for 0% Deductible and Specified Deductible (2019 FHCF Exposure Data)

See Below

The following table shows the loss costs per $1,000 for specified deductibles.

Form A-4: Hurricane Output Ranges
Hurricane Loss Costs per $1,000 for 0% Deductible

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Alachua	LOW	0.281	0.232	2.490	0.260	0.140	0.250	0.140	0.109
Alachua	AVERAGE	0.778	0.738	5.028	0.556	0.396	0.679	0.464	0.578
Alachua	HIGH	1.220	0.980	9.706	0.904	0.600	0.967	0.647	0.937
Baker	LOW	0.216	0.195	1.684	0.204	0.150	NA	NA	0.319
Baker	AVERAGE	0.501	0.453	3.361	0.439	0.294	NA	NA	0.319
Baker	HIGH	0.696	0.559	5.921	0.516	0.348	NA	NA	0.319
Bay	LOW	0.583	0.596	5.344	0.840	0.551	1.306	0.545	0.587
Bay	AVERAGE	4.790	4.009	20.020	3.667	2.597	7.481	4.470	4.647
Bay	HIGH	11.233	9.294	52.352	9.312	6.286	10.091	6.845	8.119
Bradford	LOW	0.254	0.265	2.172	0.281	0.199	NA	NA	NA
Bradford	AVERAGE	0.751	0.682	4.490	0.626	0.405	NA	NA	NA
Bradford	HIGH	0.936	0.751	7.792	0.690	0.456	NA	NA	NA
Brevard	LOW	0.698	0.550	6.766	0.653	0.385	0.815	0.262	0.312
Brevard	AVERAGE	3.915	3.125	27.415	3.437	2.291	3.904	3.273	3.226
Brevard	HIGH	11.913	9.906	55.242	9.535	6.472	10.364	7.070	8.619
Broward	LOW	0.547	0.462	10.767	0.484	0.302	0.545	0.326	0.336
Broward	AVERAGE	7.427	5.206	39.151	4.282	3.545	5.518	4.005	4.271
Broward	HIGH	20.215	16.992	76.664	16.400	11.257	16.942	12.264	14.349
Calhoun	LOW	0.612	0.442	4.116	0.508	0.394	NA	NA	NA
Calhoun	AVERAGE	1.436	1.256	7.620	1.084	0.778	NA	NA	NA
Calhoun	HIGH	2.170	1.747	15.668	1.298	0.859	NA	NA	NA
Charlotte	LOW	0.686	0.548	5.512	0.820	0.434	0.635	0.308	0.313
Charlotte	AVERAGE	3.464	2.316	14.103	2.314	1.520	3.551	1.590	1.706
Charlotte	HIGH	8.562	7.119	41.353	6.674	4.552	7.280	4.992	6.297
Citrus	LOW	0.465	0.309	3.820	0.438	0.280	0.471	0.394	0.333
Citrus	AVERAGE	1.514	1.053	8.451	1.024	0.686	1.376	0.919	1.070
Citrus	HIGH	1.980	1.597	13.791	1.465	0.964	1.615	1.069	1.523
Clay	LOW	0.246	0.208	2.303	0.257	0.180	0.236	0.193	0.231
Clay	AVERAGE	0.702	0.697	4.492	0.607	0.417	0.541	0.380	0.580
Clay	HIGH	1.146	0.922	9.050	0.852	0.567	0.939	0.628	0.907
Collier	LOW	0.715	0.603	7.710	0.527	0.301	0.583	0.210	0.427
Collier	AVERAGE	4.864	3.344	24.886	3.424	2.468	5.118	3.151	2.848
Collier	HIGH	14.761	12.388	60.906	11.852	8.180	12.878	8.933	10.658
Columbia	LOW	0.239	0.180	1.991	0.219	0.179	0.571	0.326	0.327
Columbia	AVERAGE	0.646	0.570	3.931	0.495	0.357	0.602	0.416	0.327
Columbia	HIGH	0.956	0.770	7.808	0.715	0.479	0.634	0.429	0.327
DeSoto	LOW	0.680	0.542	6.832	0.968	0.483	1.149	0.525	0.958
DeSoto	AVERAGE	2.510	1.852	13.022	1.994	1.117	1.569	1.087	1.214
DeSoto	HIGH	2.989	2.405	21.777	2.182	1.427	2.046	1.585	1.934
Dixie	LOW	0.440	0.372	2.822	0.367	0.584	0.459	0.333	0.455
Dixie	AVERAGE	1.196	0.832	6.116	0.825	0.598	0.967	0.629	0.903
Dixie	HIGH	3.536	2.918	20.070	0.948	0.771	1.387	0.937	1.248

Form A-4: Hurricane Output Ranges
Hurricane Loss Costs per $1,000 for 0% Deductible

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Duval	LOW	0.225	0.189	1.960	0.223	0.114	0.257	0.104	0.125
Duval	AVERAGE	0.926	0.835	4.901	0.674	0.489	0.678	0.536	0.630
Duval	HIGH	2.940	2.407	19.463	2.272	1.616	2.357	1.601	2.129
Escambia	LOW	0.453	0.401	4.773	0.523	0.423	1.208	0.606	1.057
Escambia	AVERAGE	4.564	4.377	19.407	3.659	2.743	6.154	4.129	4.679
Escambia	HIGH	11.744	9.678	56.609	11.238	6.422	10.431	7.009	8.562
Flagler	LOW	0.320	0.256	3.278	0.336	0.260	0.456	0.231	0.295
Flagler	AVERAGE	1.831	1.150	10.179	1.139	0.722	2.251	0.965	0.866
Flagler	HIGH	4.285	3.484	25.915	3.332	2.187	3.644	2.407	3.243
Franklin	LOW	1.880	1.797	11.316	2.525	2.236	1.947	1.885	3.545
Franklin	AVERAGE	6.087	6.235	27.165	5.645	4.428	3.902	4.007	3.983
Franklin	HIGH	9.492	7.860	43.553	7.881	5.310	8.250	5.703	6.642
Gadsden	LOW	0.302	0.252	2.462	0.296	0.233	NA	NA	0.421
Gadsden	AVERAGE	0.863	0.781	5.359	0.768	0.522	NA	NA	0.738
Gadsden	HIGH	1.205	0.969	9.637	0.909	0.571	NA	NA	0.912
Gilchrist	LOW	0.399	0.357	2.859	0.352	0.321	NA	NA	NA
Gilchrist	AVERAGE	0.954	0.855	5.758	0.833	0.575	NA	NA	NA
Gilchrist	HIGH	1.345	1.087	10.092	1.008	0.676	NA	NA	NA
Glades	LOW	1.250	0.726	9.178	1.056	0.878	NA	NA	1.604
Glades	AVERAGE	3.400	2.206	17.712	2.633	1.637	NA	NA	2.267
Glades	HIGH	3.953	3.174	28.415	2.884	1.881	NA	NA	3.143
Gulf	LOW	0.725	0.826	4.771	0.865	1.307	1.276	0.903	0.899
Gulf	AVERAGE	4.147	4.590	18.148	4.723	3.390	3.197	1.517	3.421
Gulf	HIGH	7.666	6.295	38.446	6.228	4.153	6.769	4.538	5.628
Hamilton	LOW	0.232	0.190	1.687	0.206	0.163	NA	NA	NA
Hamilton	AVERAGE	0.525	0.467	3.000	0.445	0.301	NA	NA	NA
Hamilton	HIGH	0.698	0.560	6.095	0.516	0.349	NA	NA	NA
Hardee	LOW	0.664	0.488	6.218	0.730	0.519	2.076	NA	1.081
Hardee	AVERAGE	2.293	1.729	12.094	1.711	1.128	2.076	NA	1.081
Hardee	HIGH	2.661	2.134	19.962	1.931	1.263	2.076	NA	1.081
Hendry	LOW	0.929	0.744	7.239	1.062	0.672	1.826	0.839	1.643
Hendry	AVERAGE	3.759	2.769	18.907	2.905	1.717	3.683	2.058	2.201
Hendry	HIGH	5.110	4.102	35.232	3.747	2.421	4.137	2.691	3.303
Hernando	LOW	0.507	0.359	4.084	0.435	0.323	1.402	0.363	0.558
Hernando	AVERAGE	2.178	1.522	11.716	1.300	0.916	2.252	1.425	1.299
Hernando	HIGH	4.459	3.671	23.405	3.463	2.320	3.529	2.551	3.347
Highlands	LOW	0.832	0.473	6.111	0.669	0.425	0.844	0.478	0.443
Highlands	AVERAGE	2.389	1.827	16.176	1.713	1.139	2.015	1.336	1.360
Highlands	HIGH	4.054	3.254	29.301	2.971	1.932	2.855	1.867	2.816
Hillsborough	LOW	0.511	0.408	5.198	0.413	0.289	0.510	0.293	0.285
Hillsborough	AVERAGE	2.231	1.871	12.657	1.708	1.172	1.897	1.398	1.367
Hillsborough	HIGH	6.302	5.205	29.979	4.878	3.285	5.329	3.611	4.249

Form A-4: Hurricane Output Ranges

Hurricane Loss Costs per $1,000 for 0% Deductible

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Holmes	LOW	0.500	0.451	3.709	0.444	0.356	NA	NA	0.826
Holmes	AVERAGE	1.205	1.102	6.550	0.962	0.702	NA	NA	0.826
Holmes	HIGH	1.485	1.193	11.897	1.110	0.738	NA	NA	0.826
Indian River	LOW	1.006	0.805	9.896	1.241	0.352	1.144	0.623	0.889
Indian River	AVERAGE	7.003	3.740	28.614	5.567	2.970	6.536	4.755	4.402
Indian River	HIGH	14.505	12.099	51.637	11.656	7.950	12.661	8.681	10.457
Jackson	LOW	0.382	0.318	2.809	0.391	0.268	NA	NA	0.462
Jackson	AVERAGE	1.093	0.966	6.235	0.890	0.615	NA	NA	0.782
Jackson	HIGH	1.729	1.390	13.348	1.301	0.862	NA	NA	1.078
Jefferson	LOW	0.261	0.262	2.105	0.251	0.199	NA	NA	NA
Jefferson	AVERAGE	0.652	0.560	3.949	0.558	0.390	NA	NA	NA
Jefferson	HIGH	0.891	0.716	7.408	0.670	0.448	NA	NA	NA
Lafayette	LOW	0.367	0.320	2.432	0.719	0.251	NA	NA	NA
Lafayette	AVERAGE	0.841	0.716	4.497	0.767	0.466	NA	NA	NA
Lafayette	HIGH	1.027	0.827	8.030	0.777	0.519	NA	NA	NA
Lake	LOW	0.400	0.316	3.547	0.347	0.202	0.485	0.329	0.353
Lake	AVERAGE	1.499	1.136	12.344	1.012	0.694	1.566	0.950	1.107
Lake	HIGH	2.585	2.072	19.745	1.882	1.235	1.985	1.313	1.836
Lee	LOW	0.592	0.492	5.967	0.653	0.309	0.541	0.254	0.372
Lee	AVERAGE	4.441	2.100	21.230	1.992	1.434	3.821	1.900	1.825
Lee	HIGH	13.140	11.042	54.232	10.465	7.247	11.380	7.922	9.501
Leon	LOW	0.278	0.225	2.408	0.264	0.171	0.292	0.115	0.123
Leon	AVERAGE	0.867	0.761	5.512	0.620	0.414	0.555	0.453	0.509
Leon	HIGH	1.158	0.932	9.041	0.875	0.583	0.911	0.644	0.922
Levy	LOW	0.404	0.365	3.290	0.443	0.301	1.369	1.297	0.756
Levy	AVERAGE	1.547	1.039	6.632	1.003	0.770	3.245	2.258	1.373
Levy	HIGH	4.943	4.077	26.197	3.914	2.651	4.269	2.905	3.677
Liberty	LOW	0.490	0.499	3.737	0.524	0.816	NA	NA	NA
Liberty	AVERAGE	1.233	1.107	7.191	1.027	0.816	NA	NA	NA
Liberty	HIGH	1.621	1.305	12.306	1.232	0.816	NA	NA	NA
Madison	LOW	0.211	0.216	1.757	0.194	0.155	NA	NA	NA
Madison	AVERAGE	0.629	0.539	3.716	0.499	0.353	NA	NA	NA
Madison	HIGH	0.775	0.622	6.507	0.581	0.391	NA	NA	NA
Manatee	LOW	0.604	0.509	5.017	0.478	0.319	0.508	0.212	0.370
Manatee	AVERAGE	3.769	2.289	17.787	2.707	1.657	3.968	2.560	1.388
Manatee	HIGH	11.140	9.336	47.162	8.378	6.080	9.117	6.650	7.677
Marion	LOW	0.338	0.243	2.636	0.331	0.233	0.409	0.227	0.281
Marion	AVERAGE	1.207	0.823	7.529	0.823	0.540	0.999	0.661	0.715
Marion	HIGH	1.597	1.281	12.679	1.174	0.770	1.295	0.855	1.270
Martin	LOW	1.052	0.888	10.190	1.909	0.779	1.997	0.596	0.990
Martin	AVERAGE	8.597	5.452	47.081	5.417	4.043	10.180	5.320	5.231
Martin	HIGH	14.622	12.077	67.821	11.777	7.873	12.800	8.606	10.647

Form A-4: Hurricane Output Ranges

Hurricane Loss Costs per $1,000 for 0% Deductible

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Miami-Dade	LOW	0.557	0.470	11.005	0.822	0.158	0.492	0.175	0.259
Miami-Dade	AVERAGE	7.874	5.617	35.033	5.054	4.352	6.552	4.577	4.425
Miami-Dade	HIGH	26.939	22.761	70.258	20.760	15.246	23.800	16.584	18.853
Monroe	LOW	4.102	3.234	32.437	4.242	2.286	7.116	2.128	2.150
Monroe	AVERAGE	19.758	17.526	90.047	20.282	13.667	22.515	12.734	12.956
Monroe	HIGH	29.929	25.549	98.798	24.938	17.704	26.912	19.181	20.558
Nassau	LOW	0.209	0.156	1.627	0.183	0.126	0.517	0.214	0.231
Nassau	AVERAGE	1.004	0.797	4.280	0.791	0.538	1.231	0.926	0.859
Nassau	HIGH	2.035	1.664	13.653	1.550	1.055	1.701	1.162	1.572
Okaloosa	LOW	0.365	0.401	3.853	0.445	0.334	0.620	1.100	0.635
Okaloosa	AVERAGE	5.285	4.680	13.600	4.488	3.182	7.289	5.166	5.102
Okaloosa	HIGH	13.063	10.821	58.889	10.874	7.336	11.774	7.983	9.380
Okeechobee	LOW	1.118	0.835	10.410	1.476	0.931	0.921	1.568	1.671
Okeechobee	AVERAGE	4.807	3.489	29.628	3.846	2.235	3.489	3.391	3.221
Okeechobee	HIGH	6.778	5.472	42.517	5.098	3.300	5.605	3.653	5.260
Orange	LOW	0.420	0.335	4.341	0.334	0.117	0.353	0.138	0.182
Orange	AVERAGE	1.319	1.204	11.796	0.931	0.652	1.073	0.748	0.953
Orange	HIGH	2.455	1.968	18.828	1.787	1.176	1.883	1.247	1.870
Osceola	LOW	0.449	0.359	4.652	0.450	0.255	0.439	0.178	0.228
Osceola	AVERAGE	1.443	1.358	13.645	0.979	0.764	1.143	0.726	0.884
Osceola	HIGH	3.215	2.576	23.954	2.347	1.406	2.264	1.492	2.561
Palm Beach	LOW	0.964	0.803	10.265	0.848	0.290	0.778	0.397	0.563
Palm Beach	AVERAGE	8.750	5.660	41.411	5.774	4.223	8.102	4.841	4.280
Palm Beach	HIGH	19.169	16.011	77.578	15.625	10.632	16.940	11.585	13.688
Pasco	LOW	0.511	0.423	4.617	0.422	0.347	0.443	0.320	0.432
Pasco	AVERAGE	1.923	2.203	13.111	1.387	1.342	1.752	2.107	1.627
Pasco	HIGH	6.175	5.125	31.035	4.812	3.267	4.912	3.583	4.543
Pinellas	LOW	0.699	0.582	5.866	0.690	0.442	0.749	0.386	0.460
Pinellas	AVERAGE	5.320	4.246	23.530	3.268	2.538	4.314	3.040	2.799
Pinellas	HIGH	9.933	8.330	39.045	7.874	5.444	8.566	5.954	7.191
Polk	LOW	0.430	0.363	4.685	0.376	0.267	0.508	0.253	0.357
Polk	AVERAGE	1.624	1.261	12.032	1.098	0.822	1.195	0.891	0.911
Polk	HIGH	2.742	2.198	19.441	1.929	1.309	2.204	1.454	2.126
Putnam	LOW	0.323	0.254	2.578	0.348	0.232	0.383	0.220	0.242
Putnam	AVERAGE	0.977	0.821	6.249	0.771	0.523	0.765	0.481	0.739
Putnam	HIGH	1.587	1.271	12.768	1.083	0.718	1.198	0.797	1.197
Saint Johns	LOW	0.320	0.271	2.873	0.300	0.143	0.282	0.180	0.249
Saint Johns	AVERAGE	1.239	1.348	8.272	1.292	0.874	1.774	1.386	1.403
Saint Johns	HIGH	3.858	3.137	23.696	2.996	1.984	3.277	2.183	2.926
Saint Lucie	LOW	0.907	0.766	12.255	1.136	0.508	1.425	0.545	0.678
Saint Lucie	AVERAGE	6.352	3.108	36.244	4.025	2.366	6.623	4.304	3.990
Saint Lucie	HIGH	15.600	12.974	69.781	12.582	8.514	13.666	9.297	11.275

Form A-4: Hurricane Output Ranges

Hurricane Loss Costs per $1,000 for 0% Deductible

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Santa Rosa	LOW	0.475	0.527	4.991	0.560	0.501	2.026	1.726	0.707
Santa Rosa	AVERAGE	4.651	3.834	20.864	4.628	3.046	9.207	6.388	4.186
Santa Rosa	HIGH	15.713	13.027	70.248	13.014	8.807	14.096	9.586	11.281
Sarasota	LOW	0.592	0.499	5.014	0.704	0.315	0.658	0.360	0.454
Sarasota	AVERAGE	4.276	2.822	22.992	2.942	2.036	4.662	2.842	1.842
Sarasota	HIGH	9.110	7.654	39.822	7.218	5.004	7.855	5.473	6.615
Seminole	LOW	0.395	0.334	4.233	0.346	0.213	0.349	0.186	0.158
Seminole	AVERAGE	1.410	1.194	11.279	0.979	0.673	1.111	0.779	0.940
Seminole	HIGH	1.972	1.580	15.625	1.438	0.949	1.589	1.007	1.508
Sumter	LOW	0.384	0.320	4.036	0.384	0.249	0.540	0.228	0.329
Sumter	AVERAGE	0.831	0.636	9.672	0.635	0.407	1.034	0.505	0.501
Sumter	HIGH	1.906	1.527	14.808	1.386	0.914	1.375	0.910	1.366
Suwannee	LOW	0.266	0.252	2.160	0.249	0.195	NA	NA	0.189
Suwannee	AVERAGE	0.719	0.612	4.076	0.565	0.411	NA	NA	0.477
Suwannee	HIGH	1.052	0.847	8.387	0.789	0.528	NA	NA	0.797
Taylor	LOW	0.334	0.331	2.579	0.364	0.224	0.460	0.474	0.670
Taylor	AVERAGE	1.038	0.870	6.217	0.743	0.534	0.788	0.537	0.801
Taylor	HIGH	2.055	1.671	13.607	0.897	1.068	1.749	0.752	1.582
Union	LOW	0.271	0.266	2.096	0.259	0.202	NA	NA	NA
Union	AVERAGE	0.651	0.587	3.757	0.538	0.399	NA	NA	NA
Union	HIGH	0.868	0.696	7.289	0.643	0.430	NA	NA	NA
Volusia	LOW	0.337	0.284	3.540	0.289	0.201	0.300	0.283	0.192
Volusia	AVERAGE	2.257	1.622	13.104	1.523	1.032	2.621	1.965	1.570
Volusia	HIGH	5.604	4.581	32.080	4.399	2.908	4.802	3.192	4.191
Wakulla	LOW	0.411	0.330	3.463	0.449	0.300	0.587	2.503	0.545
Wakulla	AVERAGE	1.275	1.234	7.397	1.093	1.055	2.296	2.949	1.193
Wakulla	HIGH	5.099	4.207	24.263	4.132	2.780	4.497	3.042	3.183
Walton	LOW	0.496	0.392	4.554	0.519	0.432	1.330	0.896	0.986
Walton	AVERAGE	4.200	2.985	14.681	3.833	2.424	7.286	3.615	4.885
Walton	HIGH	11.604	9.621	53.437	9.481	6.432	10.287	7.014	8.392
Washington	LOW	0.562	0.572	4.390	0.592	0.387	0.975	NA	0.725
Washington	AVERAGE	1.505	1.422	7.886	1.410	0.946	0.975	NA	0.815
Washington	HIGH	2.711	2.186	18.784	2.074	1.363	0.975	NA	1.056
Statewide	LOW	0.209	0.156	1.627	0.183	0.114	0.236	0.104	0.109
Statewide	AVERAGE	2.841	3.020	14.931	1.906	2.078	3.090	3.286	2.663
Statewide	HIGH	29.929	25.549	98.798	24.938	17.704	26.912	19.181	20.558

Form A-4: Hurricane Output Ranges

Hurricane Loss Costs per $1,000 with Specified Deductibles

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Alachua	LOW	0.210	0.175	1.904	0.199	0.102	0.190	0.100	0.072
Alachua	AVERAGE	0.582	0.550	4.188	0.415	0.298	0.504	0.342	0.389
Alachua	HIGH	0.930	0.739	8.459	0.682	0.457	0.728	0.484	0.628
Baker	LOW	0.164	0.148	1.250	0.157	0.112	NA	NA	0.221
Baker	AVERAGE	0.375	0.339	2.712	0.330	0.222	NA	NA	0.221
Baker	HIGH	0.522	0.418	4.965	0.389	0.263	NA	NA	0.221
Bay	LOW	0.431	0.443	4.346	0.613	0.408	0.965	0.399	0.401
Bay	AVERAGE	4.023	3.310	18.271	3.021	2.159	6.476	3.808	3.588
Bay	HIGH	9.923	8.113	49.490	8.177	5.528	8.877	5.969	6.477
Bradford	LOW	0.192	0.198	1.644	0.213	0.148	NA	NA	NA
Bradford	AVERAGE	0.563	0.509	3.699	0.470	0.305	NA	NA	NA
Bradford	HIGH	0.702	0.559	6.660	0.516	0.344	NA	NA	NA
Brevard	LOW	0.531	0.415	5.488	0.494	0.291	0.613	0.188	0.209
Brevard	AVERAGE	3.189	2.536	25.031	2.805	1.890	3.198	2.716	2.439
Brevard	HIGH	10.490	8.640	51.892	8.336	5.677	9.060	6.141	6.867
Broward	LOW	0.423	0.357	8.912	0.385	0.231	0.427	0.236	0.240
Broward	AVERAGE	6.269	4.295	36.223	3.512	2.974	4.509	3.296	3.299
Broward	HIGH	18.274	15.232	72.845	14.721	10.133	15.132	10.936	11.898
Calhoun	LOW	0.443	0.325	3.283	0.367	0.289	NA	NA	NA
Calhoun	AVERAGE	1.083	0.937	6.536	0.801	0.587	NA	NA	NA
Calhoun	HIGH	1.684	1.330	14.134	0.967	0.651	NA	NA	NA
Charlotte	LOW	0.507	0.407	4.429	0.611	0.327	0.480	0.222	0.211
Charlotte	AVERAGE	2.825	1.838	12.480	1.838	1.217	2.911	1.249	1.241
Charlotte	HIGH	7.456	6.139	38.601	5.750	3.951	6.274	4.282	4.940
Citrus	LOW	0.347	0.231	3.046	0.331	0.209	0.356	0.292	0.230
Citrus	AVERAGE	1.180	0.808	7.306	0.788	0.531	1.061	0.704	0.748
Citrus	HIGH	1.567	1.248	12.275	1.142	0.757	1.258	0.825	1.062
Clay	LOW	0.185	0.157	1.756	0.195	0.134	0.181	0.142	0.158
Clay	AVERAGE	0.528	0.524	3.703	0.458	0.316	0.406	0.282	0.395
Clay	HIGH	0.876	0.699	7.820	0.647	0.434	0.710	0.472	0.614
Collier	LOW	0.537	0.455	6.321	0.406	0.225	0.443	0.151	0.300
Collier	AVERAGE	4.060	2.745	22.670	2.804	2.051	4.304	2.614	2.178
Collier	HIGH	13.155	10.937	57.474	10.478	7.263	11.390	7.855	8.634
Columbia	LOW	0.179	0.136	1.495	0.167	0.133	0.418	0.238	0.223
Columbia	AVERAGE	0.483	0.424	3.206	0.369	0.268	0.444	0.306	0.223
Columbia	HIGH	0.722	0.578	6.700	0.538	0.364	0.471	0.317	0.223
DeSoto	LOW	0.505	0.403	5.563	0.712	0.359	0.847	0.385	0.662
DeSoto	AVERAGE	1.936	1.406	11.342	1.514	0.853	1.175	0.814	0.848
DeSoto	HIGH	2.352	1.863	19.577	1.680	1.111	1.550	1.212	1.311

Form A-4: Hurricane Output Ranges

Hurricane Loss Costs per $1,000 with Specified Deductibles

Modeling Organization: AIR Worldwide
Hurricane Model Name & Version Number: AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Dixie	LOW	0.327	0.276	2.224	0.275	0.451	0.340	0.245	0.306
Dixie	AVERAGE	0.935	0.635	5.223	0.631	0.464	0.758	0.489	0.633
Dixie	HIGH	2.965	2.422	18.303	0.725	0.618	1.106	0.742	0.888
Duval	LOW	0.170	0.142	1.481	0.171	0.082	0.197	0.073	0.083
Duval	AVERAGE	0.718	0.644	4.092	0.520	0.380	0.521	0.413	0.441
Duval	HIGH	2.417	1.962	17.554	1.856	1.331	1.913	1.295	1.549
Escambia	LOW	0.340	0.302	3.734	0.386	0.311	0.876	0.446	0.696
Escambia	AVERAGE	3.756	3.583	17.486	2.965	2.257	5.160	3.446	3.495
Escambia	HIGH	10.303	8.384	53.440	9.873	5.594	9.089	6.050	6.769
Flagler	LOW	0.238	0.191	2.533	0.256	0.193	0.331	0.164	0.198
Flagler	AVERAGE	1.460	0.893	8.834	0.893	0.565	1.813	0.753	0.616
Flagler	HIGH	3.562	2.863	23.606	2.752	1.809	3.008	1.965	2.398
Franklin	LOW	1.513	1.444	9.934	2.057	1.857	1.556	1.536	2.802
Franklin	AVERAGE	5.253	5.389	25.195	4.878	3.871	3.286	3.444	3.153
Franklin	HIGH	8.377	6.858	41.096	6.921	4.671	7.233	4.971	5.253
Gadsden	LOW	0.225	0.188	1.888	0.220	0.172	NA	NA	0.277
Gadsden	AVERAGE	0.641	0.576	4.500	0.565	0.390	NA	NA	0.484
Gadsden	HIGH	0.901	0.716	8.416	0.668	0.431	NA	NA	0.594
Gilchrist	LOW	0.301	0.266	2.234	0.266	0.244	NA	NA	NA
Gilchrist	AVERAGE	0.732	0.653	4.878	0.638	0.445	NA	NA	NA
Gilchrist	HIGH	1.046	0.837	8.859	0.776	0.526	NA	NA	NA
Glades	LOW	0.913	0.542	7.516	0.777	0.652	NA	NA	1.113
Glades	AVERAGE	2.633	1.664	15.622	1.993	1.254	NA	NA	1.535
Glades	HIGH	3.090	2.437	25.794	2.193	1.449	NA	NA	2.138
Gulf	LOW	0.526	0.600	3.854	0.627	1.038	0.987	0.684	0.636
Gulf	AVERAGE	3.478	3.862	16.577	4.007	2.893	2.636	1.200	2.593
Gulf	HIGH	6.649	5.387	36.064	5.356	3.577	5.834	3.871	4.369
Hamilton	LOW	0.174	0.143	1.247	0.156	0.120	NA	NA	NA
Hamilton	AVERAGE	0.388	0.344	2.391	0.330	0.224	NA	NA	NA
Hamilton	HIGH	0.516	0.412	5.119	0.381	0.260	NA	NA	NA
Hardee	LOW	0.496	0.366	4.963	0.541	0.387	1.560	NA	0.747
Hardee	AVERAGE	1.756	1.306	10.440	1.293	0.861	1.560	NA	0.747
Hardee	HIGH	2.073	1.640	17.799	1.477	0.975	1.560	NA	0.747
Hendry	LOW	0.690	0.556	5.843	0.788	0.503	1.321	0.608	1.154
Hendry	AVERAGE	2.949	2.119	16.821	2.215	1.324	2.815	1.555	1.523
Hendry	HIGH	4.050	3.186	32.317	2.880	1.880	3.190	2.053	2.226
Hernando	LOW	0.387	0.271	3.240	0.331	0.244	1.095	0.270	0.393
Hernando	AVERAGE	1.768	1.211	10.359	1.027	0.732	1.828	1.143	0.955
Hernando	HIGH	3.786	3.084	21.366	2.916	1.963	2.950	2.131	2.545

Form A-4: Hurricane Output Ranges
Hurricane Loss Costs per $1,000 with Specified Deductibles

Modeling Organization:	AIR Worldwide
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Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Highlands	LOW	0.607	0.356	4.820	0.497	0.316	0.615	0.348	0.305
Highlands	AVERAGE	1.815	1.366	14.202	1.274	0.860	1.497	0.990	0.937
Highlands	HIGH	3.170	2.501	26.590	2.265	1.491	2.168	1.407	1.910
Hillsborough	LOW	0.383	0.307	4.165	0.320	0.221	0.399	0.218	0.194
Hillsborough	AVERAGE	1.806	1.495	11.156	1.371	0.947	1.521	1.115	0.992
Hillsborough	HIGH	5.428	4.439	27.702	4.161	2.818	4.543	3.058	3.270
Holmes	LOW	0.366	0.329	2.894	0.325	0.260	NA	NA	0.561
Holmes	AVERAGE	0.896	0.814	5.510	0.702	0.524	NA	NA	0.561
Holmes	HIGH	1.114	0.883	10.432	0.815	0.551	NA	NA	0.561
Indian River	LOW	0.749	0.601	8.225	0.921	0.260	0.848	0.455	0.628
Indian River	AVERAGE	5.919	3.069	26.051	4.671	2.476	5.512	4.008	3.403
Indian River	HIGH	12.858	10.621	48.318	10.249	7.017	11.139	7.590	8.405
Jackson	LOW	0.283	0.236	2.133	0.288	0.197	NA	NA	0.308
Jackson	AVERAGE	0.808	0.710	5.242	0.648	0.457	NA	NA	0.513
Jackson	HIGH	1.309	1.036	11.840	0.963	0.649	NA	NA	0.703
Jefferson	LOW	0.195	0.194	1.598	0.187	0.147	NA	NA	NA
Jefferson	AVERAGE	0.485	0.415	3.247	0.414	0.292	NA	NA	NA
Jefferson	HIGH	0.667	0.532	6.384	0.498	0.336	NA	NA	NA
Lafayette	LOW	0.274	0.238	1.876	0.541	0.188	NA	NA	NA
Lafayette	AVERAGE	0.639	0.541	3.737	0.582	0.356	NA	NA	NA
Lafayette	HIGH	0.785	0.627	6.946	0.591	0.398	NA	NA	NA
Lake	LOW	0.299	0.238	2.718	0.260	0.147	0.369	0.243	0.239
Lake	AVERAGE	1.130	0.846	10.765	0.752	0.522	1.170	0.705	0.745
Lake	HIGH	1.988	1.571	17.617	1.420	0.943	1.491	0.981	1.228
Lee	LOW	0.443	0.369	4.804	0.505	0.233	0.415	0.186	0.257
Lee	AVERAGE	3.707	1.648	19.230	1.566	1.139	3.143	1.519	1.335
Lee	HIGH	11.711	9.753	51.019	9.252	6.439	10.060	6.967	7.706
Leon	LOW	0.207	0.168	1.851	0.195	0.127	0.217	0.082	0.081
Leon	AVERAGE	0.649	0.566	4.670	0.458	0.310	0.407	0.333	0.339
Leon	HIGH	0.877	0.697	7.908	0.653	0.441	0.678	0.479	0.611
Levy	LOW	0.298	0.269	2.596	0.328	0.224	1.088	1.041	0.525
Levy	AVERAGE	1.231	0.798	5.660	0.772	0.606	2.719	1.881	1.004
Levy	HIGH	4.220	3.447	24.075	3.318	2.260	3.622	2.448	2.814
Liberty	LOW	0.358	0.363	2.972	0.377	0.618	NA	NA	NA
Liberty	AVERAGE	0.926	0.825	6.169	0.761	0.618	NA	NA	NA
Liberty	HIGH	1.232	0.976	10.935	0.918	0.618	NA	NA	NA
Madison	LOW	0.159	0.160	1.303	0.148	0.114	NA	NA	NA
Madison	AVERAGE	0.468	0.400	3.028	0.372	0.265	NA	NA	NA
Madison	HIGH	0.578	0.462	5.526	0.433	0.293	NA	NA	NA

Form A-4: Hurricane Output Ranges
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Hurricane Model Platform & Version Number: Touchstone 2020
Hurricane Model Release Date: 10/1/2020

County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Manatee	LOW	0.452	0.382	4.044	0.367	0.241	0.385	0.152	0.257
Manatee	AVERAGE	3.167	1.873	16.083	2.250	1.376	3.364	2.147	1.041
Manatee	HIGH	9.885	8.213	44.264	7.360	5.377	8.010	5.822	6.186
Marion	LOW	0.251	0.182	2.002	0.246	0.173	0.307	0.168	0.189
Marion	AVERAGE	0.917	0.618	6.414	0.621	0.410	0.749	0.496	0.486
Marion	HIGH	1.237	0.980	11.116	0.896	0.592	0.988	0.645	0.865
Martin	LOW	0.794	0.673	8.369	1.418	0.586	1.527	0.432	0.682
Martin	AVERAGE	7.328	4.537	43.895	4.505	3.407	8.797	4.482	4.071
Martin	HIGH	12.927	10.557	64.065	10.328	6.915	11.224	7.479	8.537
Miami-Dade	LOW	0.429	0.362	9.134	0.612	0.114	0.389	0.123	0.175
Miami-Dade	AVERAGE	6.660	4.649	32.249	4.236	3.703	5.495	3.832	3.456
Miami-Dade	HIGH	24.668	20.679	66.548	18.817	13.883	21.640	14.982	15.957
Monroe	LOW	3.450	2.692	29.886	3.654	1.937	6.107	1.697	1.594
Monroe	AVERAGE	18.019	15.887	86.470	18.567	12.505	20.634	11.477	10.978
Monroe	HIGH	27.765	23.528	95.379	23.016	16.343	24.859	17.607	17.728
Nassau	LOW	0.158	0.117	1.223	0.139	0.092	0.408	0.160	0.162
Nassau	AVERAGE	0.791	0.623	3.556	0.623	0.426	0.972	0.732	0.610
Nassau	HIGH	1.636	1.327	12.088	1.235	0.851	1.353	0.923	1.120
Okaloosa	LOW	0.274	0.299	3.002	0.332	0.247	0.450	0.823	0.419
Okaloosa	AVERAGE	4.488	3.952	12.110	3.781	2.709	6.289	4.434	3.943
Okaloosa	HIGH	11.621	9.522	55.733	9.621	6.496	10.435	7.012	7.579
Okeechobee	LOW	0.827	0.624	8.597	1.085	0.694	0.687	1.170	1.158
Okeechobee	AVERAGE	3.842	2.729	26.923	3.022	1.761	2.725	2.679	2.310
Okeechobee	HIGH	5.552	4.403	39.325	4.082	2.659	4.498	2.898	3.787
Orange	LOW	0.314	0.252	3.359	0.260	0.084	0.271	0.097	0.119
Orange	AVERAGE	0.983	0.891	10.212	0.688	0.487	0.788	0.548	0.635
Orange	HIGH	1.887	1.492	16.746	1.349	0.899	1.412	0.931	1.253
Osceola	LOW	0.337	0.272	3.609	0.339	0.193	0.335	0.128	0.151
Osceola	AVERAGE	1.081	1.011	11.879	0.727	0.573	0.841	0.533	0.594
Osceola	HIGH	2.492	1.963	21.545	1.775	1.077	1.713	1.121	1.732
Palm Beach	LOW	0.717	0.604	8.447	0.645	0.215	0.588	0.290	0.378
Palm Beach	AVERAGE	7.457	4.715	38.332	4.823	3.576	6.858	4.032	3.296
Palm Beach	HIGH	17.244	14.271	73.582	13.971	9.525	15.130	10.279	11.272
Pasco	LOW	0.388	0.322	3.699	0.331	0.266	0.342	0.239	0.301
Pasco	AVERAGE	1.554	1.811	11.626	1.112	1.111	1.407	1.750	1.221
Pasco	HIGH	5.354	4.404	28.756	4.133	2.824	4.195	3.060	3.552
Pinellas	LOW	0.540	0.449	4.854	0.541	0.344	0.587	0.287	0.322
Pinellas	AVERAGE	4.575	3.605	21.593	2.751	2.165	3.666	2.575	2.178
Pinellas	HIGH	8.814	7.329	36.566	6.928	4.816	7.539	5.215	5.805

Form A-4: Hurricane Output Ranges

Hurricane Loss Costs per $1,000 with Specified Deductibles

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Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Polk	LOW	0.324	0.275	3.642	0.293	0.197	0.377	0.182	0.244
Polk	AVERAGE	1.223	0.939	10.410	0.817	0.620	0.887	0.658	0.619
Polk	HIGH	2.097	1.657	17.292	1.442	0.994	1.649	1.083	1.416
Putnam	LOW	0.241	0.191	1.968	0.261	0.171	0.279	0.161	0.162
Putnam	AVERAGE	0.728	0.607	5.253	0.570	0.391	0.561	0.351	0.490
Putnam	HIGH	1.201	0.948	11.207	0.802	0.539	0.885	0.586	0.792
Saint Johns	LOW	0.243	0.206	2.232	0.234	0.105	0.217	0.130	0.173
Saint Johns	AVERAGE	0.982	1.068	7.134	1.033	0.700	1.428	1.111	1.015
Saint Johns	HIGH	3.191	2.567	21.528	2.462	1.637	2.691	1.777	2.152
Saint Lucie	LOW	0.683	0.579	10.319	0.837	0.385	1.067	0.406	0.478
Saint Lucie	AVERAGE	5.257	2.478	33.354	3.252	1.922	5.551	3.596	3.058
Saint Lucie	HIGH	13.853	11.403	66.035	11.083	7.520	12.041	8.131	9.089
Santa Rosa	LOW	0.356	0.392	3.931	0.416	0.367	1.599	1.344	0.466
Santa Rosa	AVERAGE	3.884	3.163	18.898	3.868	2.563	8.019	5.509	3.189
Santa Rosa	HIGH	14.003	11.480	66.739	11.519	7.807	12.497	8.427	9.133
Sarasota	LOW	0.442	0.373	4.005	0.528	0.238	0.501	0.266	0.322
Sarasota	AVERAGE	3.608	2.331	21.036	2.450	1.710	3.966	2.391	1.387
Sarasota	HIGH	8.046	6.709	37.160	6.333	4.417	6.887	4.779	5.309
Seminole	LOW	0.296	0.251	3.270	0.268	0.160	0.268	0.133	0.103
Seminole	AVERAGE	1.055	0.886	9.734	0.724	0.504	0.818	0.571	0.627
Seminole	HIGH	1.500	1.187	13.752	1.077	0.719	1.187	0.746	1.003
Sumter	LOW	0.287	0.240	3.168	0.287	0.187	0.397	0.163	0.223
Sumter	AVERAGE	0.616	0.471	8.344	0.475	0.305	0.771	0.371	0.343
Sumter	HIGH	1.461	1.157	13.068	1.047	0.699	1.031	0.678	0.916
Suwannee	LOW	0.199	0.188	1.633	0.187	0.144	NA	NA	0.126
Suwannee	AVERAGE	0.537	0.454	3.340	0.420	0.308	NA	NA	0.323
Suwannee	HIGH	0.799	0.639	7.246	0.596	0.403	NA	NA	0.534
Taylor	LOW	0.250	0.245	2.005	0.272	0.166	0.343	0.357	0.460
Taylor	AVERAGE	0.799	0.663	5.327	0.563	0.410	0.604	0.408	0.553
Taylor	HIGH	1.653	1.327	12.177	0.684	0.860	1.395	0.583	1.120
Union	LOW	0.204	0.198	1.582	0.197	0.151	NA	NA	NA
Union	AVERAGE	0.486	0.437	3.044	0.403	0.301	NA	NA	NA
Union	HIGH	0.650	0.519	6.199	0.481	0.324	NA	NA	NA
Volusia	LOW	0.252	0.213	2.724	0.223	0.150	0.228	0.205	0.126
Volusia	AVERAGE	1.792	1.270	11.505	1.195	0.815	2.115	1.590	1.129
Volusia	HIGH	4.722	3.819	29.436	3.684	2.444	4.017	2.649	3.150
Wakulla	LOW	0.306	0.247	2.783	0.334	0.223	0.434	2.086	0.362
Wakulla	AVERAGE	1.005	0.971	6.439	0.856	0.858	1.895	2.485	0.869
Wakulla	HIGH	4.367	3.558	22.377	3.510	2.371	3.830	2.569	2.387

Form A-4: Hurricane Output Ranges

Hurricane Loss Costs per $1,000 with Specified Deductibles

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Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Walton	LOW	0.367	0.292	3.621	0.380	0.318	0.977	0.667	0.686
Walton	AVERAGE	3.502	2.430	13.178	3.187	2.015	6.280	3.027	3.756
Walton	HIGH	10.240	8.395	50.385	8.299	5.644	9.024	6.102	6.691
Washington	LOW	0.412	0.416	3.489	0.426	0.284	0.709	NA	0.471
Washington	AVERAGE	1.141	1.071	6.742	1.058	0.722	0.709	NA	0.543
Washington	HIGH	2.132	1.689	17.017	1.595	1.062	0.709	NA	0.729
Statewide	LOW	0.158	0.117	1.223	0.139	0.082	0.181	0.073	0.072
Statewide	AVERAGE	2.341	2.465	13.334	1.540	1.726	2.565	2.726	2.031
Statewide	HIGH	27.765	23.528	95.379	23.016	16.343	24.859	17.607	17.728

Form A-5: Percentage Change in Hurricane Output Ranges

A. One or more automated programs or scripts shall be used to generate and arrange the data in Form A-5, Percentage Change in Hurricane Output Ranges.

Form A-5 was prepared using an automated process designed to limit the amount of manual intervention and decrease time and diligence. During the automation process, AIR exercised due diligence verifying that the process reproduced the same indications as Form A-5 in prior submissions.

B. Provide summaries of the percentage change in average hurricane loss cost output range data compiled in Form A-4, Hurricane Output Ranges, relative to the equivalent data compiled from the previously-accepted hurricane model in the format shown in the file named "2019FormA5.xlsx."

For the change in hurricane output range exhibit, 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.***

The percentage change in the average loss costs relative to the equivalent data compiled from the previously accepted model is provided in Form A-5.

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 all tables in Form A-5, Percentage Change in Hurricane Output Ranges, in a submission appendix.

A hard copy of the tables in Form A-5 is included in this appendix and provided in an Excel format.

Table 48. Percentage Change in $0 Deductible Output Ranges (2017 FHCF Exposure Data)

Region	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Coastal	0.8%	0.2%	0.0%	0.3%	0.1%	0.2%	0.0%	0.1%
Inland	0.8%	0.5%	0.5%	0.4%	0.2%	0.3%	0.1%	0.6%
North	2.2%	1.8%	2.0%	1.9%	1.8%	2.3%	2.2%	2.8%
Central	0.0%	-0.1%	0.0%	-0.3%	-0.5%	-0.4%	-0.6%	-0.3%
South	-0.1%	0.4%	-0.1%	0.3%	0.2%	-0.3%	0.2%	0.2%
Statewide	0.8%	0.2%	0.1%	0.3%	0.1%	0.2%	0.0%	0.1%

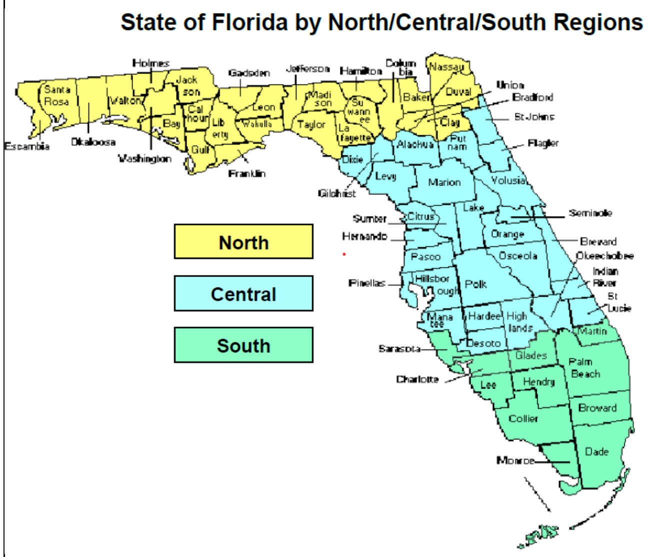
Table 49. Percentage Change in Specified Deductible Output Ranges (2017 FHCF Exposure Data)

Region	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Coastal	0.9%	0.2%	0.0%	0.3%	0.1%	0.3%	0.0%	0.2%
Inland	0.9%	0.5%	0.6%	0.4%	0.2%	0.3%	0.2%	0.6%
North	2.3%	1.9%	2.0%	1.9%	1.8%	2.3%	2.2%	2.9%
Central	0.1%	-0.1%	0.1%	-0.3%	-0.4%	-0.3%	-0.6%	-0.2%
South	0.0%	0.4%	-0.1%	0.4%	0.3%	-0.3%	0.2%	0.2%
Statewide	0.9%	0.3%	0.2%	0.4%	0.1%	0.3%	0.0%	0.2%

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 previously-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 white. The larger the percentage change in the county, the more intense the color-shade.

ROA Figure 14



ROA Figure 15

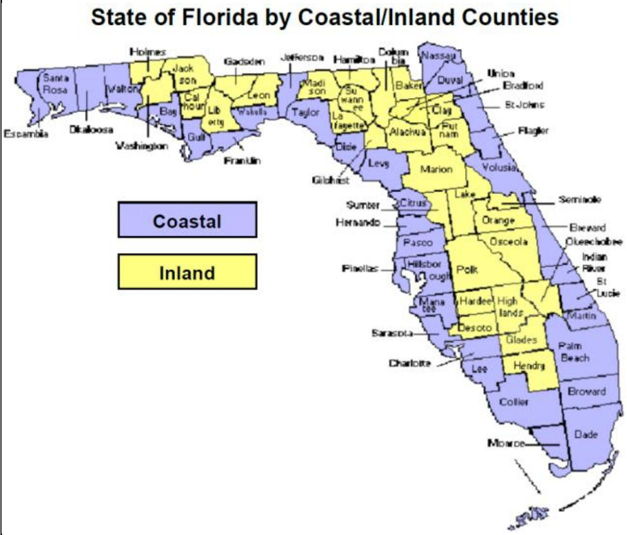


Figure 71 through Figure 78 show the percentage change in loss costs by county for the specified deductibles from the output ranges from the previously accepted model.

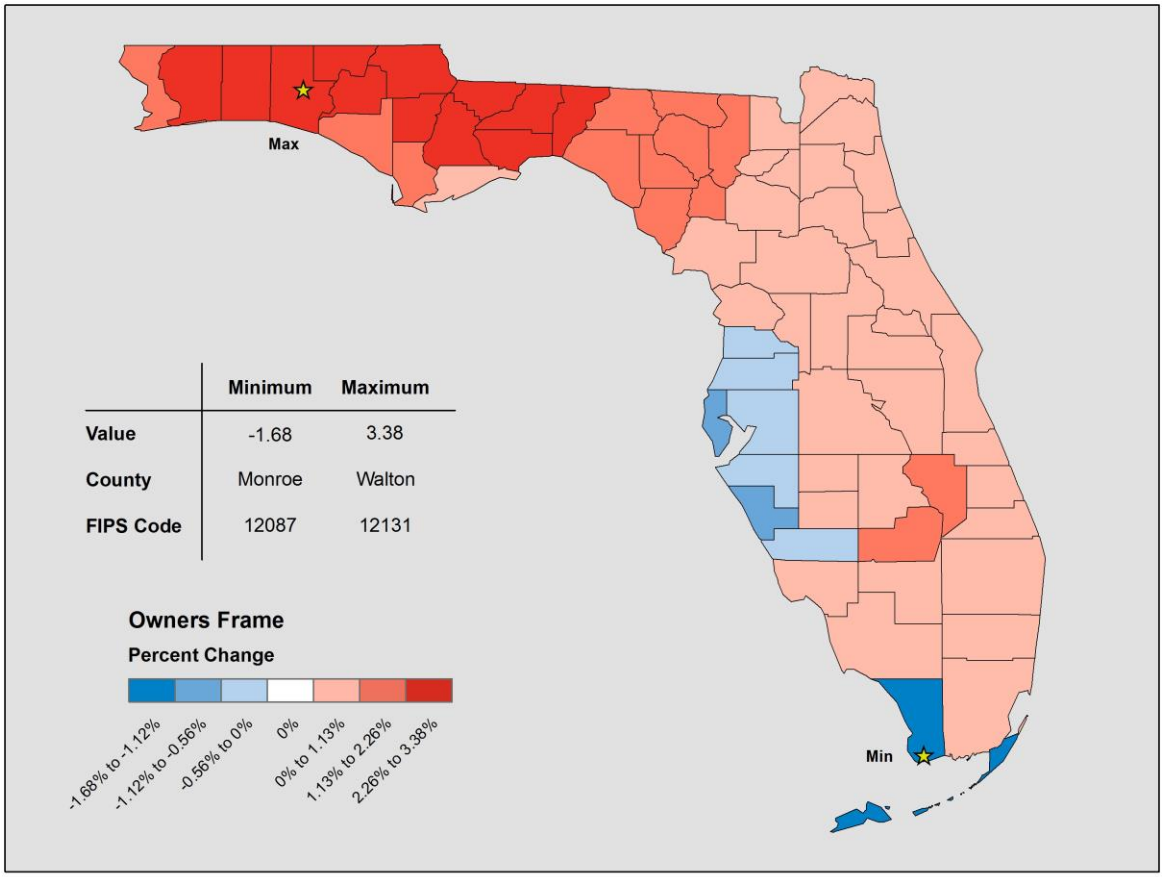
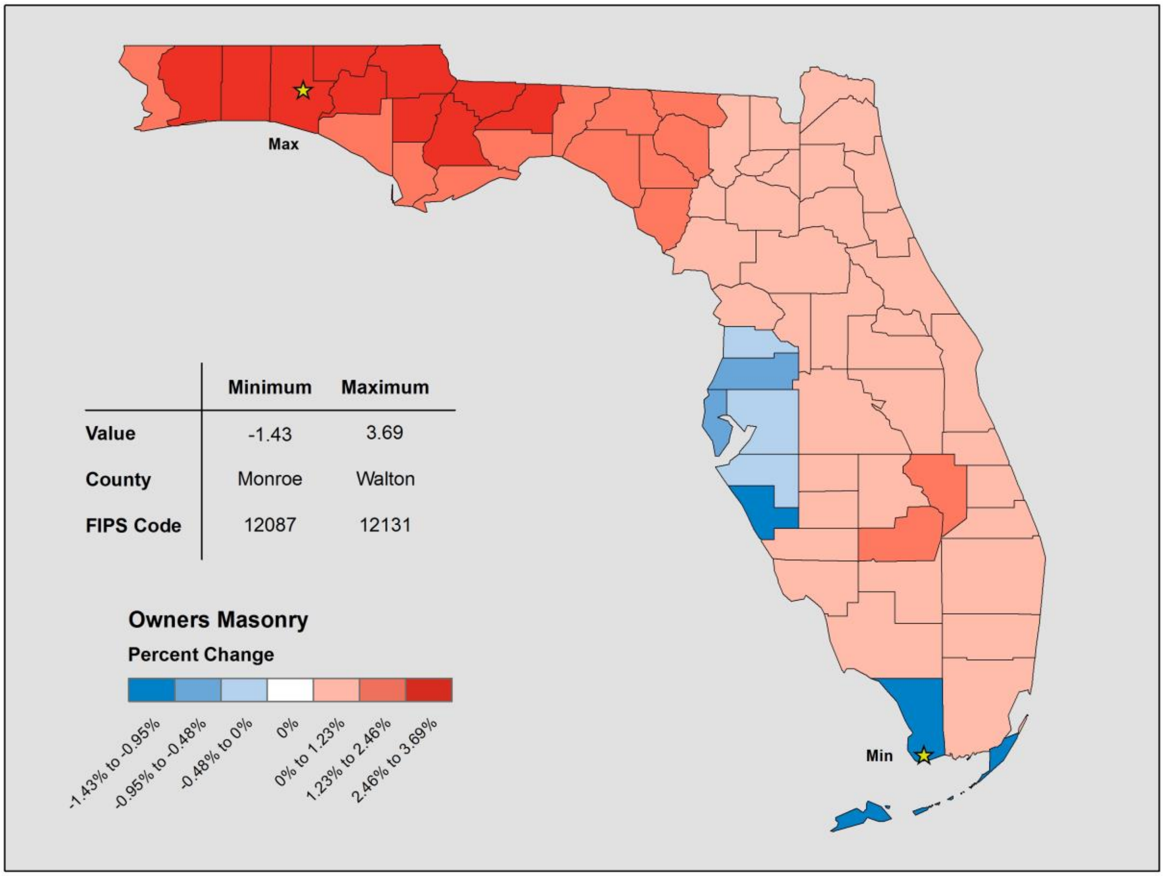
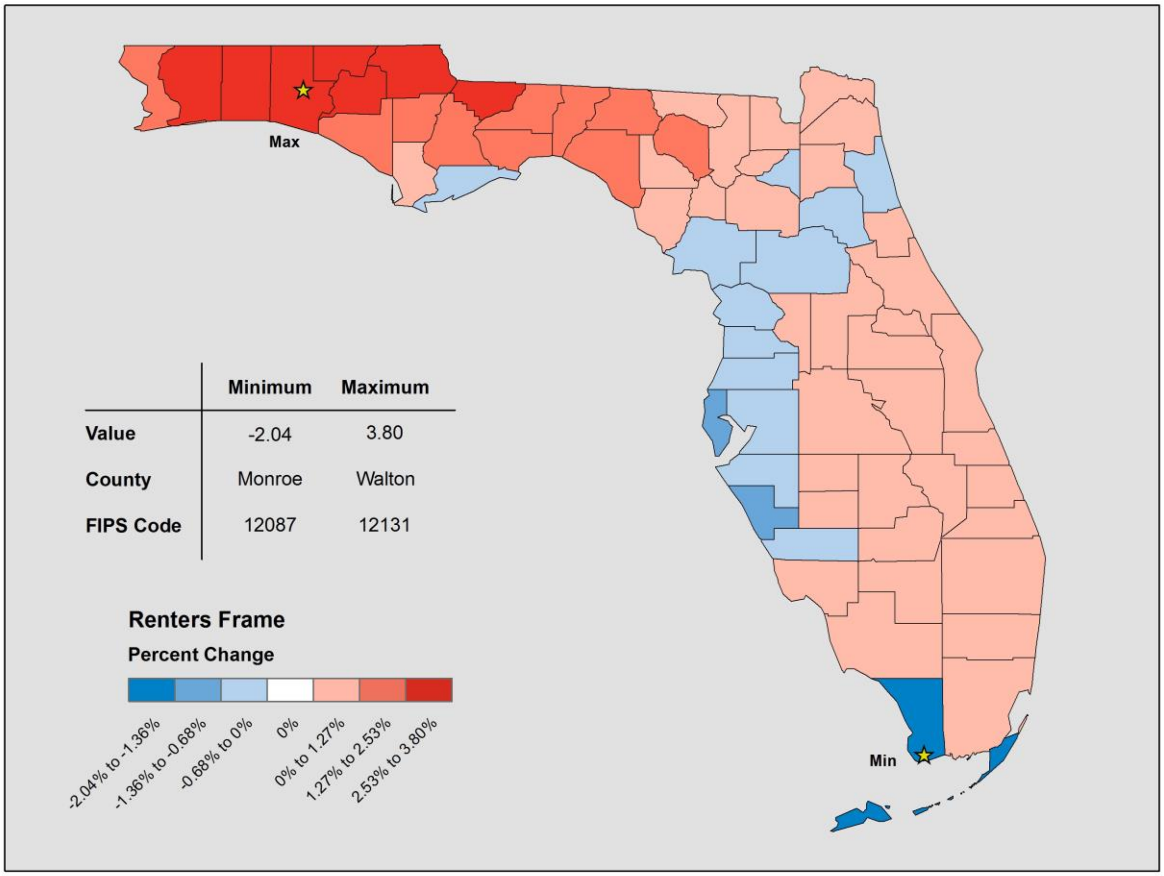


Figure 71. Percentage Change for Owners - Frame



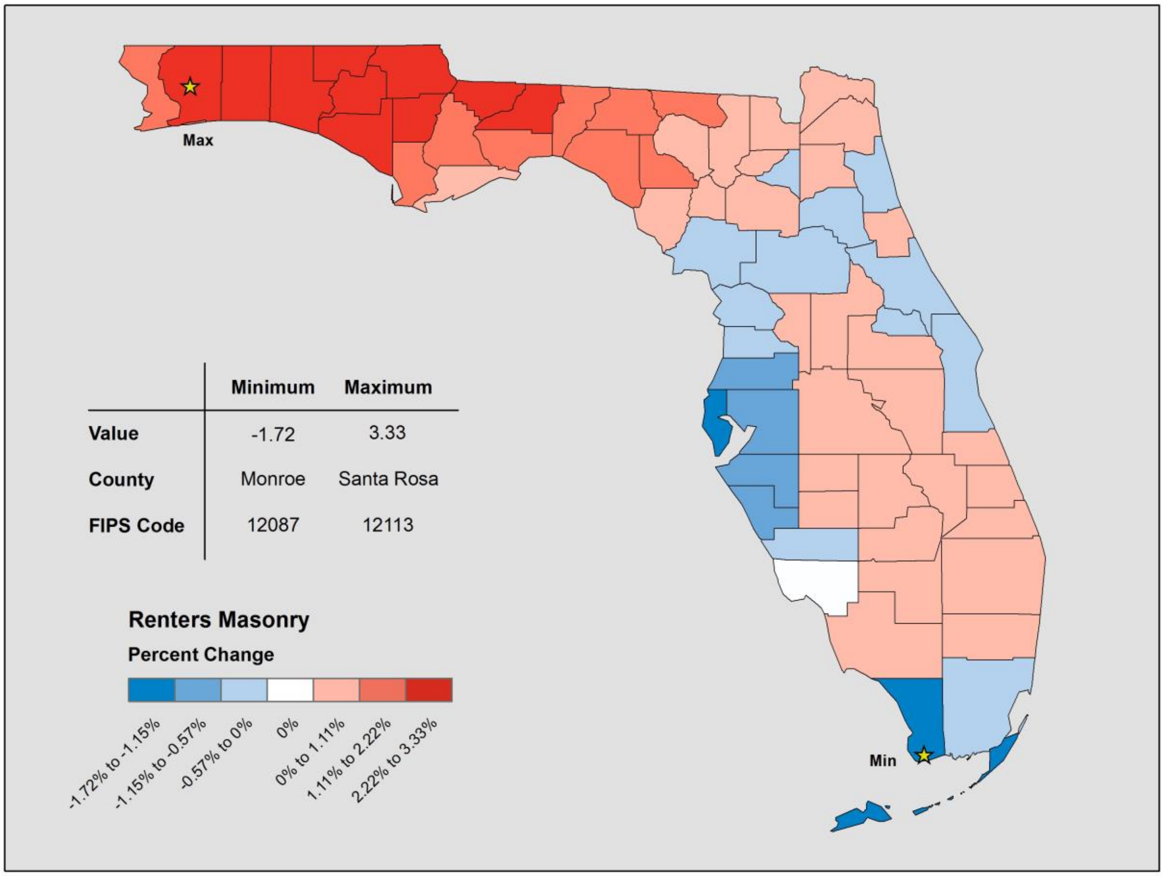
	Minimum	Maximum
Value	-1.43	3.69
County	Monroe	Walton
FIPS Code	12087	12131

Figure 72. Percentage Change for Owners - Masonry



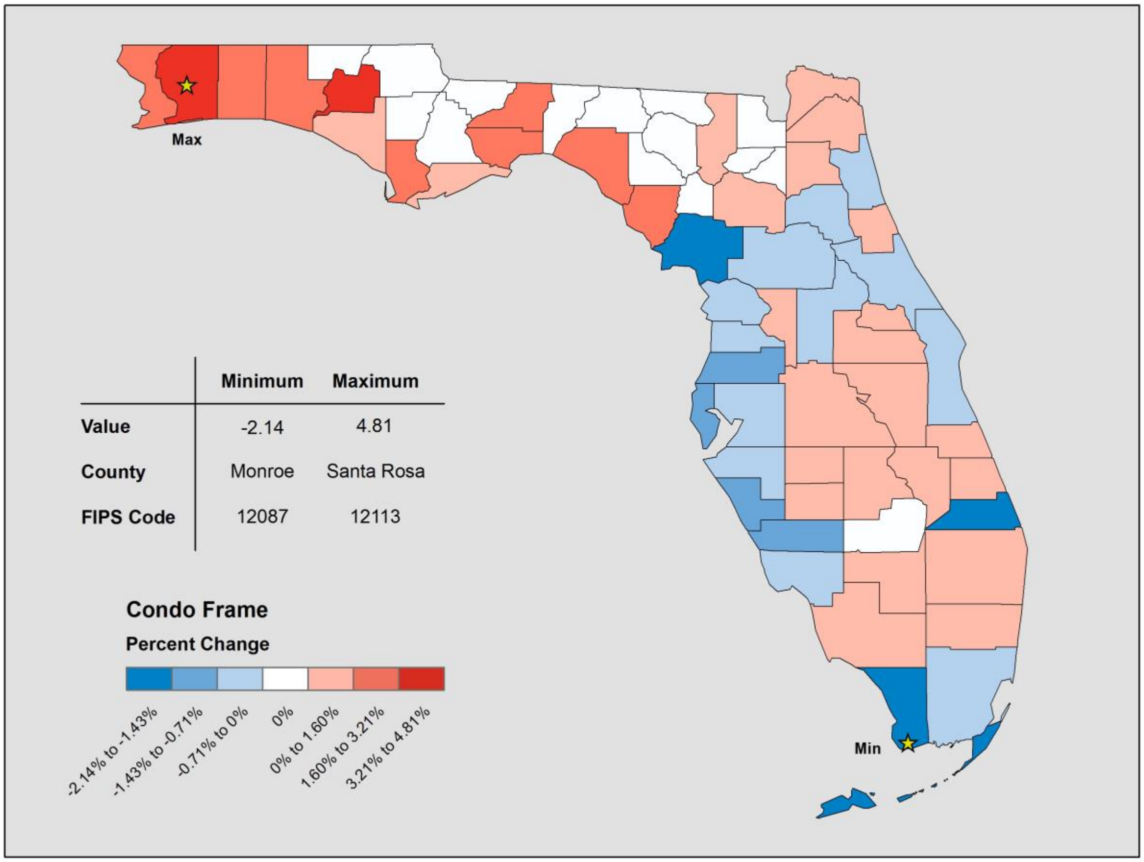
	Minimum	Maximum
Value	-2.04	3.80
County	Monroe	Walton
FIPS Code	12087	12131

Figure 73. Percentage Change for Renters – Frame



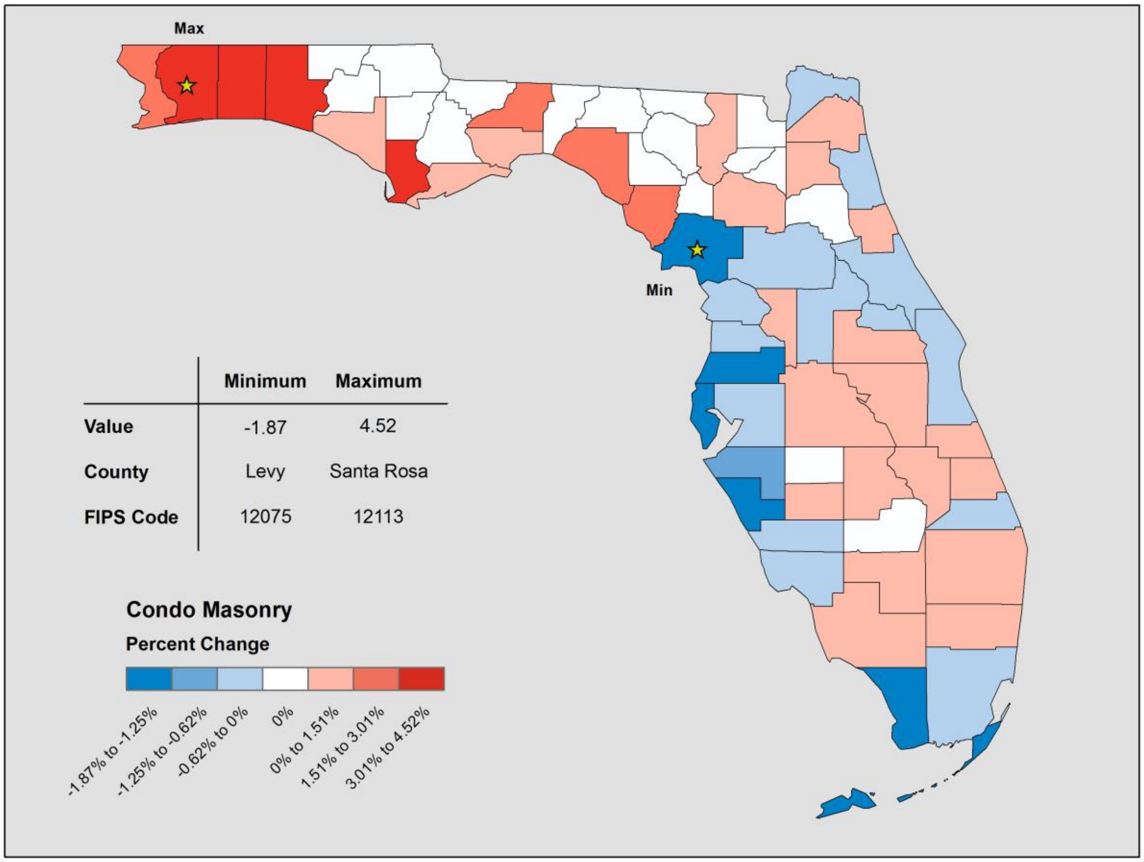
	Minimum	Maximum
Value	-1.72	3.33
County	Monroe	Santa Rosa
FIPS Code	12087	12113

Figure 74. Percentage Change for Renters – Masonry



	Minimum	Maximum
Value	-2.14	4.81
County	Monroe	Santa Rosa
FIPS Code	12087	12113

Figure 75. Percentage Change for Condo Unit Owners - Frame



	Minimum	Maximum
Value	-1.87	4.52
County	Levy	Santa Rosa
FIPS Code	12075	12113

Figure 76. Percentage Change for Condo Unit Owners - Masonry

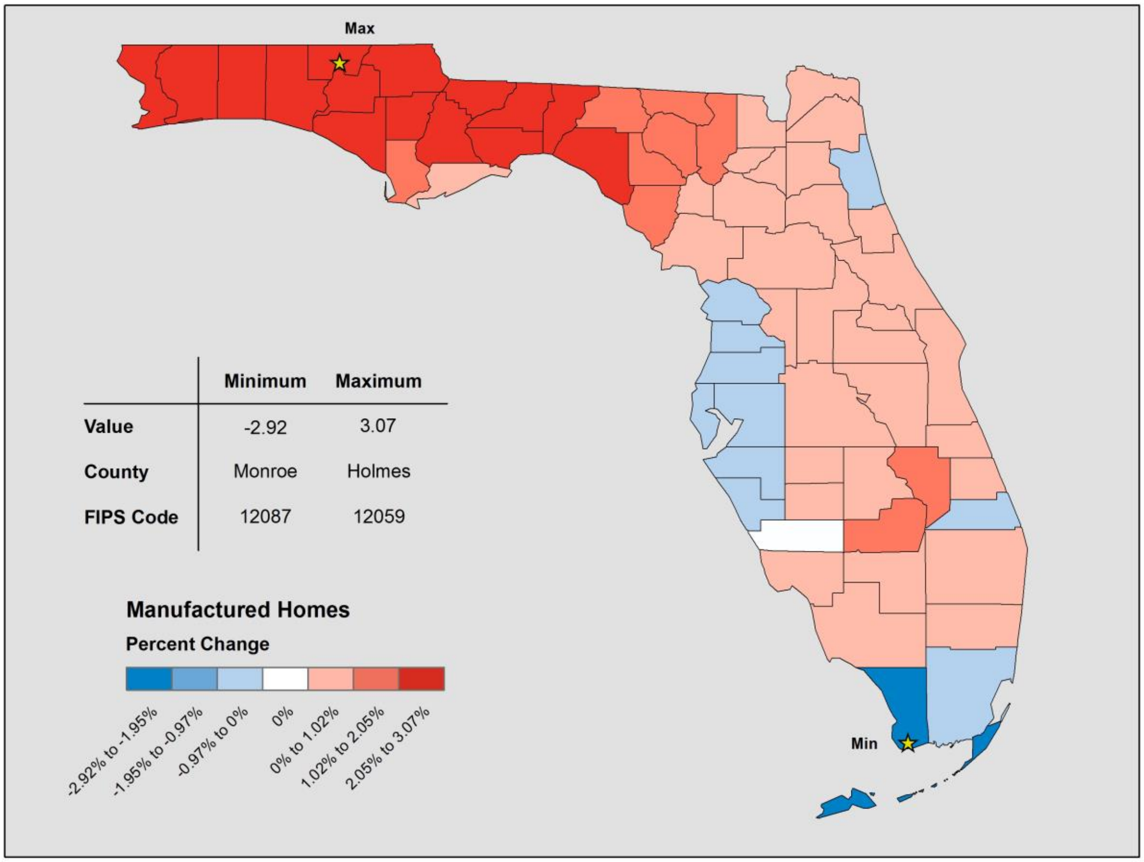
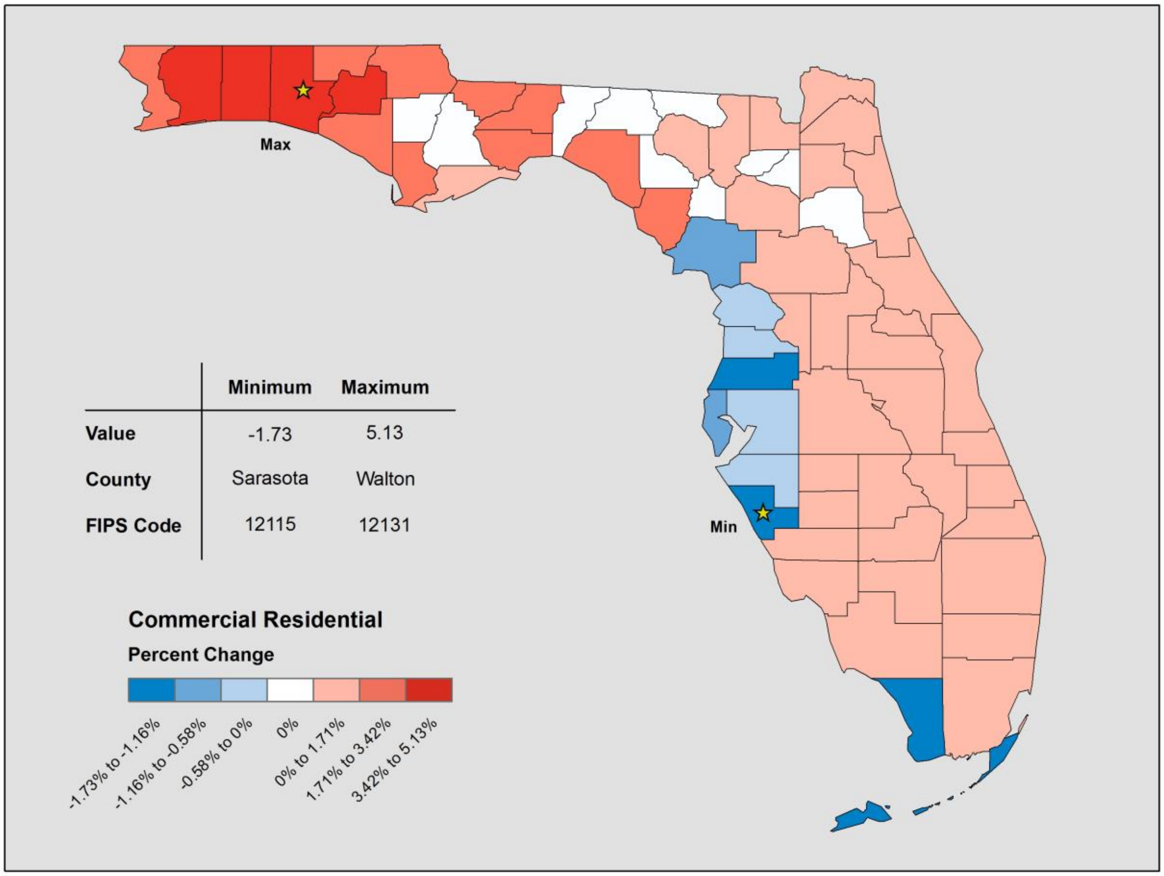


Figure 77. Percentage Change for Manufactured Home



	Minimum	Maximum
Value	-1.73	5.13
County	Sarasota	Walton
FIPS Code	12115	12131

Figure 78. Percentage Change for Commercial Residential (2017 FHCF Exposure Data)

Form A-6: Logical Relationship to Hurricane Risk (Trade Secret Item)

This will be provided to the Professional Team during the audit.

Form A-7: Percentage Change in Logical Relationship to Hurricane Risk

A. *One or more automated programs or scripts shall be used to generate the exhibits in Form A-7, Percentage Change in Logical Relationship to Hurricane Risk.*

Form A-7 was prepared using an automated process designed to limit the amount of manual intervention and decrease time and diligence. During the automation process, AIR exercised due diligence verifying that the process reproduced the same indications as Form A-7 in prior submissions.

B. *Provide summaries of the percentage change in logical relationship to hurricane risk exhibits from the previously-accepted hurricane model in the format shown in the file named "2019FormA7.xlsx."*

The exhibits showing percentage change in logical relationship to risk from the previously accepted model were prepared in the format specified and included in the submission appendix.

C. *Create exposure sets for each exhibit by modeling all of the coverages from the appropriate Notional Set listed below at each of the locations in "Location Grid B" as described in the file "NotionalInput19.xlsx." Refer to the Notional Hurricane Policy Specifications provided in Form A-6, Logical Relationship to Hurricane Risk (Trade Secret Item), for additional modeling information.*

Exhibit	Notional Set
Deductible Sensitivity	Set 1
Policy Form Sensitivity	Set 2
Construction Sensitivity	Set 3
Coverage Sensitivity	Set 4
Year Built Sensitivity	Set 5
Building Strength Sensitivity	Set 6
Number of Stories Sensitivity	Set 7

Exposure sets were created using the specifications and grid points in "NotionalInput19.xlsx", provided by the Commission.

D. *Hurricane models shall treat points in "Location Grid B" as coordinates that would result from a geocoding process. Hurricane models shall treat points by simulating hurricane loss at exact location or by using the nearest modeled parcel/street/cell in the hurricane model. Provide the results statewide (overall percentage change) and by the regions defined in Form A-5, Percentage Change in Hurricane Output Ranges*

Exposure sets were created using the specifications and grid points in NotionalInput17.xlsx provided by the Commission.

E. ***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 exhibits in Form A-7, Percentage Change in Logical Relationship to Hurricane Risk, in a submission appendix.***

A hard copy of Form A-7 is included in this appendix in Table 50 through Table 56 and is provided in Excel format.

Table 50. Percentage Change in Logical Relationship to Hurricane Risk—Deductible Sensitivity

Construction/ Policy	Region	Percent Change in Hurricane Loss Cost					
		$0	$500	1%	2%	5%	10%
Frame Owners	Coastal	0.2%	0.3%	0.3%	0.3%	0.3%	0.3%
	Inland	0.5%	0.5%	0.5%	0.5%	0.5%	0.4%
	North	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%
	Central	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
	South	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
	Statewide	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Masonry Owners	Coastal	0.2%	0.2%	0.3%	0.3%	0.3%	0.2%
	Inland	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%
	North	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%
	Central	-0.2%	-0.2%	-0.2%	-0.1%	-0.1%	-0.2%
	South	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%
	Statewide	0.2%	0.3%	0.3%	0.3%	0.3%	0.2%
Manufactured Homes	Coastal	0.2%	0.2%	0.2%	0.2%	0.3%	0.3%
	Inland	0.6%	0.7%	0.7%	0.7%	0.8%	0.8%
	North	1.9%	1.9%	1.9%	2.0%	2.0%	2.1%
	Central	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%
	South	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%
	Statewide	0.2%	0.3%	0.3%	0.3%	0.3%	0.4%
Frame Renters	Coastal	-0.1%	0.0%	0.0%	0.0%	0.0%	0.1%
	Inland	0.2%	0.2%	0.2%	0.2%	0.3%	0.3%
	North	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%
	Central	-0.5%	-0.5%	-0.5%	-0.4%	-0.4%	-0.3%
	South	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%
	Statewide	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Masonry Renters	Coastal	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%
	Inland	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%
	North	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%
	Central	-0.6%	-0.5%	-0.5%	-0.5%	-0.5%	-0.4%
	South	-0.2%	-0.2%	-0.2%	-0.2%	-0.1%	-0.1%
	Statewide	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.0%

Construction/ Policy	Region	Percent Change in Hurricane Loss Cost					
		$0	$500	1%	2%	5%	10%
Frame Condo Unit	Coastal	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
	Inland	0.2%	0.2%	0.2%	0.3%	0.3%	0.4%
	North	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%
	Central	-0.5%	-0.4%	-0.4%	-0.4%	-0.3%	-0.3%
	South	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.0%
	Statewide	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Masonry Condo Unit	Coastal	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.0%
	Inland	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%
	North	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%
	Central	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.4%
	South	-0.2%	-0.2%	-0.2%	-0.1%	-0.1%	-0.1%
	Statewide	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.0%
Construction/ Policy	Region	$0	2%	3%	5%	10%	
Commercial Residential	Coastal	0.2%	0.3%	0.3%	0.3%	0.2%	
	Inland	0.4%	0.3%	0.3%	0.2%	0.2%	
	North	1.9%	2.0%	2.0%	2.0%	2.0%	
	Central	-0.3%	-0.2%	-0.3%	-0.3%	-0.3%	
	South	0.2%	0.2%	0.2%	0.2%	0.2%	
	Statewide	0.2%	0.3%	0.3%	0.3%	0.2%	

Table 51. Percent Change in Logical Relationship to Hurricane Risk—Policy Form Sensitivity

Policy	Region	Percent Change in Hurricane Loss Cost	
		Masonry	Frame
Owners	Coastal	0.2%	0.2%
	Inland	0.5%	0.5%
	North	1.9%	1.9%
	Central	-0.2%	-0.2%
	South	0.1%	0.2%
	Statewide	0.2%	0.3%
Renters	Coastal	-0.1%	-0.1%
	Inland	0.1%	0.2%
	North	1.6%	1.7%
	Central	-0.6%	-0.5%
	South	-0.2%	-0.1%
	Statewide	-0.1%	0.0%
Condo Unit	Coastal	-0.1%	0.0%
	Inland	0.1%	0.2%
	North	1.6%	1.7%

Policy	Region	Percent Change in Hurricane Loss Cost	
		Masonry	Frame
	Central	-0.5%	-0.5%
	South	-0.2%	-0.1%
	Statewide	-0.1%	0.0%
Policy	**Region**	**Percent Change in Hurricane Loss Cost**	
		Concrete	
Commercial Residential	Coastal	0.2%	
	Inland	0.4%	
	North	1.9%	
	Central	-0.3%	
	South	0.2%	
	Statewide	0.2%	

Table 52. Percent Change in Logical Relationship to Risk—Hurricane Policy Form/Construction Sensitivity

Region	Percent Change in Hurricane Loss Cost		
	Frame Owners	Masonry Owners	Manufactured Homes
Coastal	0.2%	0.2%	0.2%
Inland	0.5%	0.5%	0.6%
North	1.9%	1.9%	1.9%
Central	-0.2%	-0.2%	-0.1%
South	0.2%	0.1%	0.1%
Statewide	0.3%	0.2%	0.2%

Table 53. Percent Change in Logical Relationship to Risk—Coverage Sensitivity

Construction/ Policy	Region	Percent Change in Hurricane Loss Cost			
		Coverage A	Coverage B	Coverage C	Coverage D
Frame Owners	Coastal	0.3%	0.3%	-0.3%	0.7%
	Inland	0.5%	0.5%	0.0%	1.3%
	North	1.9%	1.9%	1.4%	2.3%
	Central	-0.1%	-0.1%	-0.7%	0.4%
	South	0.2%	0.2%	-0.4%	0.6%
	Statewide	0.3%	0.3%	-0.3%	0.7%
Masonry Owners	Coastal	0.2%	0.2%	-0.3%	0.7%
	Inland	0.5%	0.5%	0.0%	1.3%
	North	1.9%	1.9%	1.3%	2.2%
	Central	-0.2%	-0.2%	-0.7%	0.4%
	South	0.2%	0.2%	-0.4%	0.6%
	Statewide	0.3%	0.3%	-0.3%	0.7%

Construction/ Policy	Region	Percent Change in Hurricane Loss Cost			
		Coverage A	Coverage B	Coverage C	Coverage D
Manufactured Homes	Coastal	0.2%	0.2%	-0.3%	0.9%
	Inland	0.7%	0.7%	0.0%	1.3%
	North	1.9%	1.9%	1.5%	2.5%
	Central	-0.1%	-0.1%	-0.8%	0.6%
	South	0.1%	0.1%	-0.4%	0.8%
	Statewide	0.3%	0.3%	-0.3%	0.9%
Frame Renters	Coastal	NA	NA	-0.3%	0.6%
	Inland	NA	NA	0.0%	1.2%
	North	NA	NA	1.5%	2.2%
	Central	NA	NA	-0.8%	0.4%
	South	NA	NA	-0.4%	0.5%
	Statewide	NA	NA	-0.3%	0.6%
Masonry Renters	Coastal	NA	NA	-0.4%	0.5%
	Inland	NA	NA	0.0%	1.1%
	North	NA	NA	1.5%	2.1%
	Central	NA	NA	-0.8%	0.2%
	South	NA	NA	-0.4%	0.4%
	Statewide	NA	NA	-0.3%	0.6%
Frame Condo Unit	Coastal	0.3%	NA	-0.3%	0.6%
	Inland	0.5%	NA	0.0%	1.2%
	North	1.9%	NA	1.5%	2.3%
	Central	-0.1%	NA	-0.8%	0.4%
	South	0.2%	NA	-0.4%	0.5%
	Statewide	0.3%	NA	-0.3%	0.7%
Masonry Condo Unit	Coastal	0.3%	NA	-0.4%	0.5%
	Inland	0.5%	NA	0.0%	1.1%
	North	1.9%	NA	1.4%	2.1%
	Central	-0.1%	NA	-0.8%	0.2%
	South	0.2%	NA	-0.4%	0.4%
	Statewide	0.3%	NA	-0.3%	0.5%
Commercial Residential	Coastal	0.2%	NA	-0.3%	0.6%
	Inland	0.4%	NA	0.0%	1.3%
	North	2.0%	NA	1.5%	2.2%
	Central	-0.3%	NA	-0.8%	0.1%
	South	0.2%	NA	-0.4%	0.5%
	Statewide	0.2%	NA	-0.3%	0.6%

Table 54. Percent Change in Logical Relationship to Risk—Building Code/Enforcement (Year Built) Sensitivity

Construction/ Hurricane Policy	Region	Percent Change in Hurricane Loss Cost				
		Year Built 1980	Year Built 1989	Year Built 1998	Year Built 2004	Year Built 2019
Frame Owners	Coastal	0.2%	0.2%	0.6%	1.4%	0.0%
	Inland	0.5%	0.5%	0.9%	1.7%	0.3%
	North	1.9%	1.9%	2.3%	3.1%	1.6%
	Central	-0.2%	-0.2%	0.3%	1.1%	-0.3%
	South	0.2%	0.2%	0.5%	1.3%	-0.1%
	Statewide	0.3%	0.3%	0.7%	1.5%	0.1%
Masonry Owners	Coastal	0.2%	0.2%	0.6%	1.4%	0.0%
	Inland	0.5%	0.5%	0.9%	1.7%	0.3%
	North	1.9%	1.9%	2.3%	3.1%	1.6%
	Central	-0.2%	-0.2%	0.3%	1.0%	-0.4%
	South	0.1%	0.1%	0.5%	1.3%	-0.1%
	Statewide	0.2%	0.2%	0.7%	1.5%	0.1%
Construction/ Hurricane Policy	**Region**	**Year Built 1989**	**Year Built 1972**	**Year Built 1992**	**Year Built 2004**	**Year Built 2019**
Manufactured Homes	Coastal	0.2%	0.1%	0.2%	0.3%	0.3%
	Inland	0.6%	0.6%	0.6%	0.6%	0.6%
	North	1.9%	1.9%	1.9%	1.9%	1.9%
	Central	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
	South	0.1%	0.0%	0.1%	0.1%	0.1%
	Statewide	0.2%	0.2%	0.2%	0.3%	0.3%
Construction/ Hurricane Policy	**Region**	**Year Built 1980**	**Year Built 1989**	**Year Built 1998**	**Year Built 2004**	**Year Built 2019**
Frame Renters	Coastal	-0.1%	-0.1%	0.4%	1.2%	-0.2%
	Inland	0.2%	0.2%	0.6%	1.4%	0.1%
	North	1.7%	1.7%	2.1%	2.9%	1.4%
	Central	-0.5%	-0.5%	0.0%	0.8%	-0.6%
	South	-0.1%	-0.1%	0.3%	1.1%	-0.3%
	Statewide	0.0%	0.0%	0.4%	1.2%	-0.1%
Masonry Renters	Coastal	-0.1%	-0.1%	0.3%	1.1%	-0.2%
	Inland	0.1%	0.1%	0.6%	1.3%	0.1%
	North	1.6%	1.6%	2.0%	2.8%	1.3%
	Central	-0.6%	-0.6%	-0.1%	0.7%	-0.6%
	South	-0.2%	-0.2%	0.2%	1.0%	-0.4%
	Statewide	-0.1%	-0.1%	0.3%	1.2%	-0.2%
Frame Condo Unit	Coastal	0.0%	0.0%	0.4%	1.2%	-0.2%
	Inland	0.2%	0.2%	0.7%	1.4%	0.1%
	North	1.7%	1.7%	2.1%	2.9%	1.4%

Construction/ Hurricane Policy	Region	Percent Change in Hurricane Loss Cost				
		Year Built 1980	Year Built 1989	Year Built 1998	Year Built 2004	Year Built 2019
	Central	-0.5%	-0.5%	0.0%	0.8%	-0.6%
	South	-0.1%	-0.1%	0.3%	1.1%	-0.3%
	Statewide	0.0%	0.0%	0.4%	1.2%	-0.1%
Masonry Condo Unit	Coastal	-0.1%	-0.1%	0.3%	1.2%	-0.2%
	Inland	0.1%	0.1%	0.6%	1.4%	0.1%
	North	1.6%	1.6%	2.0%	2.9%	1.4%
	Central	-0.5%	-0.5%	-0.1%	0.7%	-0.6%
	South	-0.2%	-0.2%	0.2%	1.1%	-0.3%
	Statewide	-0.1%	-0.1%	0.4%	1.2%	-0.2%
Commercial Residential	Coastal	0.2%	0.2%	0.7%	1.5%	0.1%
	Inland	0.4%	0.4%	0.9%	1.8%	0.3%
	North	1.9%	1.9%	2.4%	3.3%	1.8%
	Central	-0.3%	-0.3%	0.2%	1.1%	-0.4%
	South	0.2%	0.2%	0.6%	1.4%	0.0%
	Statewide	0.2%	0.2%	0.7%	1.5%	0.1%

Table 55. Percent Change in Logical Relationship to Risk—Building Strength Sensitivity

Construction/ Hurricane Policy	Region	Percent Change in Hurricane Loss Cost		
		Weak	Medium	Strong
Frame Owners	Coastal	0.2%	0.6%	1.8%
	Inland	0.5%	0.9%	2.1%
	North	1.9%	2.3%	3.5%
	Central	-0.2%	0.3%	1.4%
	South	0.2%	0.5%	1.7%
	Statewide	0.3%	0.7%	1.8%
Masonry Owners	Coastal	0.2%	0.6%	1.8%
	Inland	0.5%	0.9%	2.1%
	North	1.9%	2.3%	3.5%
	Central	-0.2%	0.3%	1.4%
	South	0.1%	0.5%	1.7%
	Statewide	0.2%	0.7%	1.8%
Manufactured Homes	Coastal	0.1%	0.2%	0.3%
	Inland	0.6%	0.6%	0.6%
	North	1.9%	1.9%	1.9%
	Central	-0.2%	-0.1%	-0.1%
	South	0.0%	0.1%	0.1%
	Statewide	0.2%	0.2%	0.3%
Frame Renters	Coastal	-0.1%	0.4%	1.5%
	Inland	0.2%	0.6%	1.9%

Construction/ Hurricane Policy	Region	Percent Change in Hurricane Loss Cost		
		Weak	Medium	Strong
	North	1.7%	2.1%	3.2%
	Central	-0.5%	0.0%	1.1%
	South	-0.1%	0.3%	1.5%
	Statewide	0.0%	0.4%	1.6%
Masonry Renters	Coastal	-0.1%	0.3%	1.5%
	Inland	0.1%	0.6%	1.8%
	North	1.6%	2.0%	3.2%
	Central	-0.6%	-0.1%	1.1%
	South	-0.2%	0.2%	1.4%
	Statewide	-0.1%	0.3%	1.5%
Frame Condo Unit	Coastal	0.0%	0.4%	1.6%
	Inland	0.2%	0.7%	1.9%
	North	1.7%	2.1%	3.3%
	Central	-0.5%	0.0%	1.2%
	South	-0.1%	0.3%	1.5%
	Statewide	0.0%	0.4%	1.6%
Masonry Condo Unit	Coastal	-0.1%	0.3%	1.5%
	Inland	0.1%	0.6%	1.8%
	North	1.6%	2.0%	3.2%
	Central	-0.5%	-0.1%	1.1%
	South	-0.2%	0.2%	1.4%
	Statewide	-0.1%	0.4%	1.6%
Commercial Residential	Coastal	0.2%	0.7%	1.7%
	Inland	0.4%	0.9%	2.0%
	North	1.9%	2.4%	3.5%
	Central	-0.3%	0.2%	1.3%
	South	0.2%	0.6%	1.7%
	Statewide	0.2%	0.7%	1.8%

Table 56. Percent Change in Logical Relationship to Risk—Number of Stories Sensitivity

Construction/ Hurricane Policy	Region	Percent Change in Hurricane Loss Cost	
		1 Story	2 Story
Frame Owners	Coastal	0.2%	0.2%
	Inland	0.5%	0.5%
	North	1.9%	1.9%
	Central	-0.2%	-0.2%
	South	0.2%	0.1%
	Statewide	0.3%	0.2%
Masonry Owners	Coastal	0.2%	0.2%
	Inland	0.5%	0.5%
	North	1.9%	1.9%
	Central	-0.2%	-0.2%
	South	0.1%	0.1%
	Statewide	0.2%	0.2%
Frame Renters	Coastal	-0.1%	-0.1%
	Inland	0.2%	0.2%
	North	1.7%	1.7%
	Central	-0.5%	-0.5%
	South	-0.1%	-0.1%
	Statewide	0.0%	0.0%
Masonry Renters	Coastal	-0.1%	-0.1%
	Inland	0.1%	0.1%
	North	1.6%	1.6%
	Central	-0.6%	-0.6%
	South	-0.2%	-0.2%
	Statewide	-0.1%	-0.1%

Construction / Hurricane Policy	Region	Percent Change in Hurricane Lost Cost		
		5 Story	10 Story	20 Story
Commercial Residential	Coastal	0.2%	0.2%	0.2%
	Inland	0.4%	0.4%	0.4%
	North	2.0%	1.9%	1.9%
	Central	-0.2%	-0.3%	-0.3%
	South	0.2%	0.2%	0.2%
	Statewide	0.3%	0.2%	0.2%

Form A-8: Hurricane Probable Maximum Loss for Florida

A. One or more automated programs or scripts shall be used to generate and arrange the data in Form A-8, Hurricane Probable Maximum Loss for Florida.

Form A-8 was prepared using an automated process designed to limit the amount of manual intervention and decrease time and diligence. During the automation process, AIR exercised due diligence verifying that the process reproduced the same indications as Form A-8 in prior submissions.

B. Provide a detailed explanation of how the Expected Annual Hurricane Losses and Return Periods are calculated.

In Form A-8, 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 Standard A-3, Disclosure 1.

C. Complete Part A showing the personal and commercial residential hurricane probable maximum loss for Florida. For the Expected Annual Hurricane Losses column, provide personal and commercial residential, zero deductible statewide hurricane loss costs based on the 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named "hlpm2017c.zip."

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 million to - $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 should 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 should 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 should

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 should be lower than the return period for an average hurricane loss of $5,455 million associated with a $5,001-$6,000 million range.

The 2017 FHCF exposure data was 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.

D. Provide a graphical comparison of the current hurricane model Residential Return Periods hurricane loss curve to the previously-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 previously-accepted hurricane model.

A graphical comparison of the exceedance probability curves using Average Loss and Return Periods as described in Form A-8.C. for both the current and previously accepted submission is provided in Figure 79.

E. Provide the estimated hurricane loss and uncertainty interval for each of the Personal and Commercial Residential Return Periods given in Part B, Annual Aggregate, and Part C, Annual Occurrence. Describe how the uncertainty intervals are derived. Also, provide in Parts B and C, the Conditional Tail Expectation, the expected value of hurricane losses greater than the Estimated Hurricane Loss Level.

Estimated loss and uncertainty intervals are provided for each return period. The uncertainty intervals are 95% confidence intervals based on bootstrapping method, and were computed using the software MatLab. The conditional tail expectation, the expected value of losses greater than the estimated loss level are provided in Part B Annual Aggregate and Part C, Annual Occurrence. The Conditional Tail Expectation was calculated as the expected value of losses greater than the Estimated Loss level.

F. 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, Hurricane Probable Maximum Loss for Florida in a submission appendix.

A hard copy of Form A-8 is included in this appendix in Table 57, Table 58, Table 59, and Figure 79, and is provided in Excel format.

Table 57. Part A - Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida

See below

Form A-8: Hurricane Probable Maximum Loss for Florida
Part A - Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida

Modeling Organization:	AIR Worldwide
Hurricane Model Name & Version Number:	AIR Hurricane Model for the U.S. v1.0.0
Hurricane Model Platform & Version Number:	Touchstone 2020
Hurricane Model Release Date:	10/1/2020

HURRICANE LOSS RANGE (MILLIONS)			TOTAL HURRICANE LOSS	AVERAGE HURRICANE LOSS (MILLIONS)	NUMBER OF HURRICANES	EXPECTED ANNUAL HURRICANE LOSSES*	RETURN PERIOD (YEARS)
$ >0	to	$500	2,642,879	129	20,472	53	2.1
$501	to	$1,000	3,512,588	720	4,876	70	2.8
$1,001	to	$1,500	3,609,487	1,232	2,930	72	3.3
$1,501	to	$2,000	3,508,560	1,738	2,019	70	3.7
$2,001	to	$2,500	3,452,190	2,239	1,542	69	4.2
$2,501	to	$3,000	3,466,139	2,751	1,260	69	4.6
$3,001	to	$3,500	3,398,634	3,240	1,049	68	5.0
$3,501	to	$4,000	3,115,799	3,740	833	62	5.4
$4,001	to	$4,500	2,925,910	4,240	690	59	5.8
$4,501	to	$5,000	3,134,515	4,742	661	63	6.2
$5,001	to	$6,000	5,773,542	5,478	1,054	115	6.8
$6,001	to	$7,000	5,424,247	6,488	836	108	7.6
$7,001	to	$8,000	4,946,785	7,518	658	99	8.5
$8,001	to	$9,000	5,064,292	8,483	597	101	9.4
$9,001	to	$10,000	4,641,953	9,493	489	93	10.3
$10,001	to	$11,000	4,594,160	10,513	437	92	11.3
$11,001	to	$12,000	4,041,705	11,482	352	81	12.3
$12,001	to	$13,000	3,949,204	12,497	316	79	13.2
$13,001	to	$14,000	3,712,034	13,498	275	74	14.3
$14,001	to	$15,000	3,531,657	14,474	244	71	15.4
$15,001	to	$16,000	3,357,431	15,472	217	67	16.4
$16,001	to	$17,000	3,480,157	16,494	211	70	17.5
$17,001	to	$18,000	3,257,163	17,512	186	65	18.8
$18,001	to	$19,000	3,105,236	18,484	168	62	20.1
$19,001	to	$20,000	2,569,573	19,466	132	51	21.3
$20,001	to	$21,000	2,811,452	20,522	137	56	22.5
$21,001	to	$22,000	2,386,399	21,499	111	48	23.8
$22,001	to	$23,000	2,542,461	22,500	113	51	25.0
$23,001	to	$24,000	2,962,816	23,514	126	59	26.6
$24,001	to	$25,000	2,571,552	24,491	105	51	28.2
$25,001	to	$26,000	2,195,422	25,528	86	44	29.8
$26,001	to	$27,000	2,070,642	26,547	78	41	31.2
$27,001	to	$28,000	2,005,040	27,466	73	40	32.8
$28,001	to	$29,000	1,970,165	28,553	69	39	34.2
$29,001	to	$30,000	1,415,914	29,498	48	28	35.7
$30,001	to	$35,000	9,065,851	32,378	280	181	40.5
$35,001	to	$40,000	7,832,374	37,475	209	157	50.0
$40,001	to	$45,000	8,002,171	42,565	188	160	62.1
$45,001	to	$50,000	5,003,139	47,649	105	100	75.3
$50,001	to	$55,000	5,236,569	52,366	100	105	89.8
$55,001	to	$60,000	4,698,296	57,296	82	94	106.6
$60,001	to	$65,000	4,801,505	62,357	77	96	128.9
$65,001	to	$70,000	3,220,948	67,103	48	64	155.3
$70,001	to	$75,000	3,541,202	72,269	49	71	181.8
$75,001	to	$80,000	2,170,814	77,529	28	43	208.3
$80,001	to	$90,000	5,350,765	84,933	63	107	261.8
$90,001	to	$100,000	3,563,819	93,785	38	71	357.1
$100,001	to	$ Maximum	17,183,804	137,470	125	344	1,136.4
Total			196,818,960	4,389	44,842	3,936	n/a

*Personal and commercial residential zero deductible statewide loss using 2017 FHCF personal and commercial residential exposure data – file name: *hlpm2017c.exe* .

Table 58. Part B - Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida

(Annual Aggregate - 2017 FHCF Exposure Data)

Based on 100K Bootstrap			
Return Period (Years)	**Estimated Hurricane Loss Level (Millions)**	**Uncertainty Interval (Millions)**	**Conditional Tail Expectation**
Top Event	315,346	264,394 to -	--
1,000	134,872	127,988 to 147,176	178,338
500	108,245	104,559 to 117,965	149,877
250	88,626	84,274 to 92,085	123,655
100	59,428	56,699 to 62,162	92,275
50	40,295	38,694 to 41,806	70,245
20	20,424	19,681 to 21,104	45,027
10	10,167	9,877 to 10,489	29,692
5	3,593	3,473 to 3,718	17,962

Table 59. Part C - Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida

(Annual Occurrence - 2017 FHCF Exposure Data)

Based on 100K Bootstrap			
Return Period (Years)	Estimated Hurricane Loss Level (Millions)	Uncertainty Interval (Millions)	Conditional Tail Expectation
Top Event	315,346	252,096 to -	--
1,000	132,341	123,340 to 143,712	174,901
500	105,920	100,634 to 115,346	146,540
250	83,674	79,792 to 88,734	119,996
100	55,259	53,142 to 58,095	88,025
50	37,591	35,991 to 39,128	66,556
20	18,422	17,844 to 19,060	42,130
10	9,142	8,858 to 9,439	27,549
5	3,247	3,144 to 3,353	16,576

The 95% uncertainty intervals for the individual return periods were calculated using the method of bootstrapping. 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 in Form A-8B 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 95% uncertainty intervals shown in

Form A-8B represent the 0.025 and 0.975 percentiles of the 100K bootstrap distribution determined for each return period.

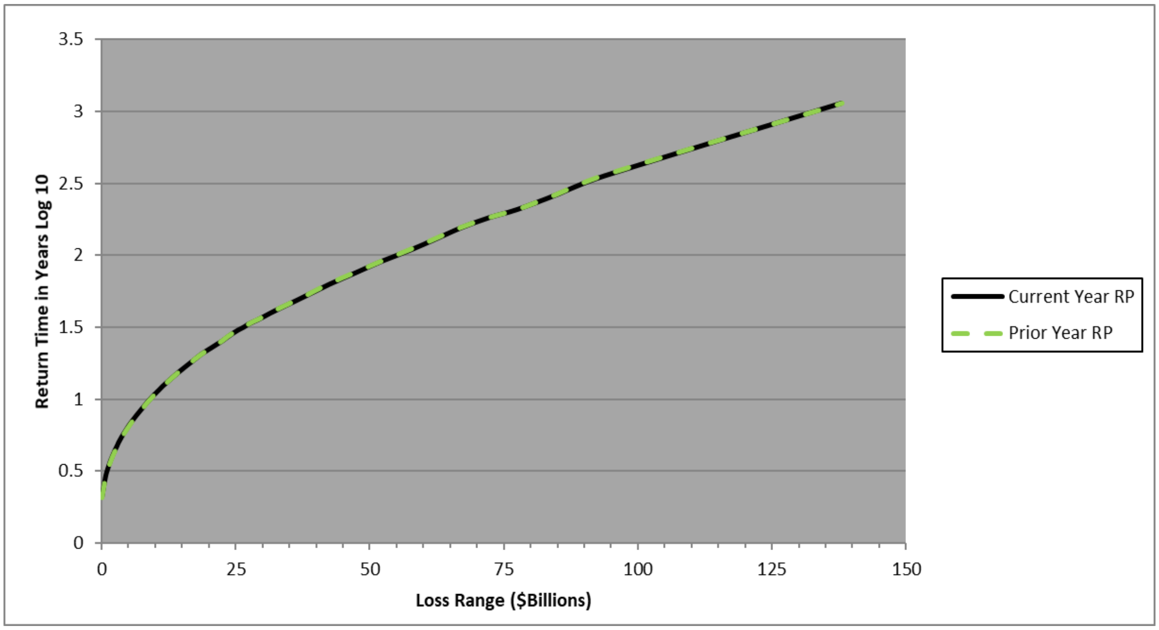


Figure 79. Part C - Personal and Commercial Residential Loss Curve Comparison

Appendix 6: Model Output Forms

Import Log

```
**************************************************************************************************************

**     The AIR Hurricane Model for the U.S. V1.0.0, as implemented in Touchstone® 2020     **

**************************************************************************************************************


********** Log header **********

Description:   [Import] initiated by [AIR-WORLDWIDE\i24270] on [CSG20FLCM2HN1]

Time Submitted: [2020-09-21 11:19:15,137]

Time Started:   [2020-09-21 11:19:15,230]

Time Ended:     [2020-09-21 11:20:54,687]

Duration:       [00:01:28]

Status:         [Completed]

Owner:          [AIR-WORLDWIDE\i24270]

Platform Name and Identification: Touchstone 2020

DataImport Version: [8.1.0.79]


********** Log Data Source Information **********

Import Type: [CSV]

Import Date Format: [Default]

Data Source:
[\\CSG20FLCM2HN1\AIRWork\IMPORT\12.FormA1_zro_ded_Notional19_ZIP2020_Contract.csv]

Data Tables: [12.FormA1_zro_ded_Notional19_ZIP2020_Contract.csv 12.Map_369c2bc8-c365-4f3a-
9b87-28fc7b5b849c 12.Default_4f0cbb65-ec7b-4534-9229-9936cff5e7e7
12.FormA1_zro_ded_Notional19_ZIP2020_Location.csv ]

Delimiter: [,]

Text Qualifier: [Double Quote]

Has Header: [Y]
```

```
********** Log Import Options **********
Destination Database         : [FCHLPM_19_TS81RC1_A_Forms_EXP]
Destination SQL Server       : [CSG20DB6\SQL2017]
Target Type                  : [Exposure Set]
Target Name                  : [FormA1_Notional19_ZIP20]
Contract Type                : [Primary]
Mapping Set                  : [FCHLPM_19_A1]
Continue Geocode with Import Errors: [Y]
Duplicate Contract           : [Skip+Error]
Location Error               : [Reject Location]
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                : [1]
Max HPC Cores                : [4]
Job Priority                 : [Normal]
Job Scheduled Time           : [Execute Immediately]
Currency                     : [USD]

Auto Exposure View: Yes
Project Name: [FCHLPM_19_TS81RC1_A_Forms]
Exposure View Name: [FormA1_Notional19_ZIP20]
Generate Exposure Summary: [Yes]
```

```
********** Log Summary Statistics **********

Elapsed Time: [00.00:01:20]

Total No. of records: [2895]

No. of records successfully processed: [2895]

Percentage of records successfully Imported: [100.00%]


********** Log Detailed Statistics **********

Summary of Property Records Imported: |

No. of Contracts                   : |[3]|

No. of Locations                   : |[2892]|

No. of Location Details            : |[2892]|

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            : |[241,000,000.00]|
Total of Replacement Value A Not Imported       : |[0.00]|
Total of Replacement Value B Imported            : |[24,100,000.00]|
Total of Replacement Value B Not Imported       : |[0.00]|
Total of Replacement Value C Imported            : |[120,500,000.00]|
Total of Replacement Value C Not Imported       : |[0.00]|
Total of Replacement Value D Imported            : |[158,337,000.00]|
Total of Replacement Value D Not Imported       : |[0.00]|
Total of Replacement Value Imported              : |[543,937,000.00]|
Total of Replacement Value Not Imported         : |[0.00]|
Total Number of Risks Imported                  : |[2,892]|


Geocode Statistics :|
GeoCoding Elapsed Time: [00.00:00:32]


[2892] locations records required geocoding
[0] locations records user retained geocodes
[0] locations records geocoded using premium geocoding
[2892] 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

[2892] 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


********* Error Summary **********

******** Business Errors *********

********** Data Errors ***********

************ Warnings ************

********* Error Details **********

********* Business Errors **********

********* Warnings **********

********* Geocoding Errors **********

********* Data Errors **********

********* Exceptions **********
```

Analysis Log

** The AIR Hurricane Model for the U.S. v1.0.0, as implemented in Touchstone® 2020 **

o Analysis Header Info

Analysis Type: Detailed Loss Analysis

Analysis Name: FormA1S2_50K_TC_WindOnly_DS_AP_AoT_202009211538

Template Name:

Analysis SID: 50

Result SID: 5

Activity ID: 105

HPC Job ID: 118

Description: N/A

User: AIR-WORLDWIDE\i24270

Time Submitted: 09/21/2020 15:38:38

Time Started: 09/21/2020 15:38:39

Time Ended: 09/21/2020 15:52:36

Duration: 00:13:57

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
    Platform Name and Identification: Touchstone 2020
    System Version:              8.1.0.79
    SQL Server Name:              CSG20DB6\SQL2017
    HPC Head Node:               CSG20FLCM2HN1

o Analysis Target Info
    Analysis Target Type:          Portfolio
    Analysis Target Name:           FormA1_Notional19_ZIP20
    Exposure View Filter:          Not Applied

    Exposure Set(s):              Database : Exposure Set Name
                                  --------   ------------------
                                  FCHLPM_19_TS81RC1_A_Forms_EXP : FormA1_Notional19_ZIP20

    Analysis Statistics:           Analyzed
                                  --------
        Policy Count:              3
        Total Location Count:        2892
            Property Location Count: 2892
            Workers Location Count:  0
        Layers Count:               0
        SubLimits Count:             0
        Reinsurance Count:            0
        Total Replacement Value:      543,937,000

o Event Set Options

    Event Set Name:               50K US Hurricane (2020) - Florida Regulatory
    Event Set Type:              Stochastic
    Event Filter:              Off
    Demand Surge:                On
    Custom Demand Surge:            No
```

```
    Min-Max Deductible Policy Logic:  Former


    Perils:                     Tropical Cyclone - Wind


    Hazard Models:                          Model:    Model Version:   Catalog:
Catalog Version:  Events:     Scenarios:

    AIR Hurricane Model for the U.S.              521      1.0.0          AIR Hurricane Model for the United
States        01.00.0810       92683       50000


o Financial Model Options
    Correlation:                   Off
    Disaggregation:                  Off
    Average Properties:              On
    Invalid Con/Occ Pairs:           Ignore
    Apply residential location terms: Deductibles before limits
    Intra-Policy Correlation factor:  0%
    Inter-Policy Correlation factor:  0%


o Reinsurance Options
    Program Name:                   N/A
    Order of application of Fac:      Apply and inure to the benefit of treaties
    FAC Reinsurance Count:            0
    Treaty Reinsurance  Count:        0


o Custom Model Options
   Custom Model:                   N/A


o Output Options
    Loss Perspectives:              Ground Up
                                     Retained
                                     Gross
                                     Net of Pre-CAT


    Event Losses By:                Portfolio
    Geography:                    Event Total
```

```
  Summary (AAL Only):            Location Summary
  Loss Details:              Coverage
  Zone Set Names:              N/A
  Save By Zone:              Off
  Zone By Peril:             Off
  Retain Annual EP By Zone:       Off
  Auto Export CLF:             No

o Analysis Management Options
  Min-Max Cores:             1-8
  Scheduled On:              Execute Immediately
  Priority:              Normal
  Processing Resource:            OnPremises
  Result Server:             CSG20DB6\SQL2017
  Result Database:             FCHLPM_19_TS81RC1_A_Forms_RES
  Results Currency Set:           AIR Default
  Results Currency:            USD
  Move Marine Craft Geocodes:      Off
  Commodity Prices
    Gas:                 2.75
    Oil:                59.83

o Flexibility Options
  No loss mod template was selected

o Terrorism Options
  Terrorism Not Covered - Coverage solely provided by Standard Fire Policies (SFP)

o Physical Properties Info
  Physical Properties computation completed at 09/21/2020 15:40:30
    Time taken for Physical Properties computation: 00:00:54
    Time taken for Post Processing of Physical Properties: 00:00:02
    Total time taken for Physical Properties processing: 00:00:56
  Physical properties were computed for all locations
```

Appendix 7: Curriculum Vitae

Carol J. Friedland, Ph.D., P.E., C.F.M.

Education

Ph.D., Civil Engineering, Minor: Disaster Science & Management, Louisiana State University, May 2009

M.S., Civil Engineering, Louisiana State University, May 2006

B.S., Civil Engineering, Minor: Spanish, University of Wyoming, May 1998

Professional Certifications

Professional Engineer in Civil Engineering, Wyoming Registration No. 10094

ASFPM Certified Floodplain Manager (CFM), National Certification No. US-12-06337

Academic Appointments

Associate Professor (2017-present), Department of Construction Management, Louisiana State University, Baton Rouge, LA

Assistant Professor (2009-2017), Department of Construction Management, Louisiana State University, Baton Rouge, LA

Part-Time Instructor (2007-2009) Department of Construction Management & Industrial Engineering, Louisiana State University, Baton Rouge, LA

Teaching Assistant (2005-2007) Department of Construction Management & Industrial Engineering, Louisiana State University, Baton Rouge, LA

Research Assistant (2003-2005) Department of Civil & Environmental Engineering, Louisiana State University, Baton Rouge, LA

Professional Appointments

Research Intern (summer 2006), *ImageCat, Inc., Long Beach, CA*

Intern (summer 2005), *Swiss Reinsurance Group, Armonk, NY*

Engineering Intern (summer 2004), *Cermak, Peterka, Petersen (CPP), Inc., Fort Collins, CO*

Project Engineer, Field Engineer, Estimator (1999-2003), *Kiewit Industrial Co., Overland Park, KS*

Staff Engineer (1998 – 1999), *MSE-HKM, Inc., Billings, MT*

Professional Contributions

Professional Affiliations

Member, American Society of Civil Engineers (ASCE), 1993-present

Member, American Association of Wind Engineers (AAWE), 2004-present

Member, Association of State Floodplain Managers, 2012-present

Member, American Society for Engineering Education, 2011-2013

Member, Sigma Lambda Chi International Construction Honor Society, 2008-present

Professional Committees and Activities

Member, ASCE Technical Council on Wind Engineering (TCWE) Structural Wind Engineering Committee (SWEC), 2010-present

Member, ASCE 7 Standard Flood Loads Subcommittee, 2012-2016; 2018-present

Member, ASCE 24 Standard Committee for Flood Resistant Design and Construction, 2010-2015; 2017-present

Member, ASCE Technical Activities Committee on Dynamic Effects, Multiple Hazard Mitigation Committee 2010-present

Steering Committee Member, 2013 Americas Conference on Wind Engineering (12ACWE)

Member, ASCE Coasts, Oceans, Ports & Rivers Institute (COPRI)

Member, ASCE Structural Engineering Institute (SEI)

Member, ASCE Energy Division, Petrochemical Committee, Task Committee on Wind-Induced Forces, 2005-2006

Publications and Presentations

Refereed Journal Publications

Ittmann, J.,* Okeil, A., & Friedland, C. (2018) The Standard of Care for the Practicing Structural Engineer. *Legal Affairs and Dispute Resolution in Engineering and Construction*, *10*(3). https://doi.org/10.1061/(ASCE)LA.1943-4170.0000265.

Orooji, F., & Friedland, C. J.* (2017). Cost-Benefit Framework to Generate Wind Hazard Mitigation Recommendations for Homeowners. *Journal of Architectural Engineering, 23*(4), (04017019-)1-11. doi:10.1061/(ASCE)AE.1943-5568.0000269

Monko, R. J.,* Berryman, C. W., & Friedland, C. J. (2017). Critical Factors for Interorganizational Collaboration and Systemic Change in BIM Adoption. *International Journal of Construction Engineering and Management, 6*(4), 111-132. doi:10.5923/j.ijcem.20170604.01

Monko, R. J.,* Berryman, C. W., & Friedland, C. J. (2017). Interorganizational Building Information Modeling (IBIM) Utilization Assessment Guide, *International Journal of Construction Engineering and Management*, *6*(3), 78-86. doi: 10.5923/j.ijcem.20170603.02

English, E. C.,* Friedland, C. J., & Orooji, F. (2017). Combined Flood and Wind Mitigation for Hurricane Damage Prevention: Case for Amphibious Construction. *Journal of Structural Engineering, 143*(6), (06017001-)1-7. doi:10.1061/(ASCE)ST.1943-541X.0001750

Matthews, E. C., Friedland, C. J.,* & Orooji, F. (2016). Integrated Environmental Sustainability and Resilience Assessment Model for Coastal Flood Hazards *Journal of Building Engineering, 8*, 141-151. doi: 10.1016/j.jobe.2016.08.002

Friedland, C.*, Joyner, T. A., Massarra, C., Rohli, R., Treviño, A., Ghosh, S., Huyck, C., & Weatherhead, M. (2016). Isotropic and anisotropic kriging approaches for interpolating surface-level wind speeds across large, geographically diverse regions. *Geomatics, Natural Hazards and Risk*. doi:10.1080/19475705.2016.1185749

Ittmann, J., Friedland, C.,* & Okeil, A. (2016). Personal liability of the practicing engineer. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*. doi:10.1061/(ASCE)LA.1943-4170.0000125

Matthews, E., Friedland, C. J.,* & Orooji, F. (2016). Optimization of sustainability and flood hazard resilience for home designs. *Procedia Engineering, 145*, 525-531. doi:10.1016/j.proeng.2016.04.040

Reed, D. A.,* Friedland, C. J., Wang, S., & Massarra, C. C. (2016). Multi-hazard system-level logit fragility functions. *Engineering Structures, 122*,14-23.

Joyner, T. A., Friedland, C. J.,* Rohli, R. V., Treviño, A. M., Massarra, C., & Paulus, G. (2015). Cross-correlation modeling of European windstorms: A cokriging approach for optimizing surface wind estimates. *Spatial Statistics, 13*, 62-75. http://dx.doi.org/10.1016/j.spasta.2015.05.003

Jiang, S., & Friedland, C. J.* (2015). Automatic urban debris zone extraction from post-hurricane very high-resolution satellite and aerial imagery. *Geomatics, Natural Hazards and Risk*, *7*(3), 933-952. doi: 10.1080/19475705.2014.1003417

Adams, S. M., Levitan, M. L.,* & Friedland, C. J. (2014). High resolution imagery collection for post-disaster studies utilizing unmanned aircraft systems (UAS). *Photogrammetric Engineering & Remote Sensing, 80*(12), 1161-1168.

Matthews, E. C., Sattler, M., & Friedland, C. J.* (2014). A critical analysis of hazard resilience measures within sustainability assessment frameworks. *Environmental Impact Assessment Review, 49*(0), 59-69. http://dx.doi.org/10.1016/j.eiar.2014.05.003

Dunn, C. L., Friedland, C. J.,* & Levitan, M. L. (2013). Statistical representation of design parameters for hurricane risk reduction structures. *Structural Safety, 45*(0), 36-47. http://dx.doi.org/10.1016/j.strusafe.2013.08.009

Ittmann, J., Friedland, C.,* & Okeil, A. (2013). Enforceability of limitation of liability clauses in engineering contracts. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 5*(3), 128-135. doi: 10.1061/(ASCE)LA.1943-4170.0000125

Bohn, F., & Friedland, C. J.* (2013). Why the 100-year flood? *Louisiana Civil Engineer, 21*(3), 16-18.

Friedland, C.,* & Gall, M. (2012). True cost of hurricanes: Case for a comprehensive understanding of multihazard building damage. *Leadership and Management in Engineering, 12*(3), 134-146. doi: 10.1061/(ASCE)LM.1943-5630.0000178

Conference Proceedings

“Mitigating wind and flood: The increased wind vulnerability of static elevation vs. amphibious retrofit,” English, E., Orooji, F., and Friedland, C.J., 8th International Colloquium on Bluff Body Aerodynamics and Applications, Boston, MA, June 7-11, 2016.

“Optimization of Sustainability and Natural Hazard Resilience for Home Designs,” Matthews, E., Friedland, C., and Orooji, F., International Conference on Sustainable Design, Engineering and Construction (ICSDEC 2016), Tempe, AZ May 18-20, 2016.

“Integration of BIM throughout an Industrial Construction Educational Track,” Friedland, C., Orooji. F., Zhu, Y., Chokwitthaya, C., Pecquet, C, and Kenney, J., Proceedings of the 10th BIM Academic Symposium, Kissimmee, FL, April 4-5, 2016.

“Amphibious Construction vs. Permanent Static Elevation: Flood Resilience Without Increased Vulnerability to Wind,” English, E., Friedland, C., and Orooji, F., 1st International Conference on Amphibious Architecture, Design & Engineering (ICAADE 2015), Bangkok, Thailand, August 26-29, 2015.

“A New Approach to Combined Flood and Wind Mitigation for Hurricane Damage Prevention,” English, E., Friedland, C., Orooji, F., and Mahtani, N., 14th International Conference on Wind Engineering (ICWE14), Porto Alegre, Brazil, June 21-26, 2015.

“Collection and organization of hurricane damage data for civil infrastructure,” Baradaranshoraka, M., C. J. Friedland & D. A. Reed. 12th Americas Conference on Wind Engineering (12ACWE). Seattle, WA, June 16-20, 2013.

“H*Wind hurricane time history extraction for defined locations,” Madani, S. A., M. Baradaranshoraka & C. J. Friedland. 12th Americas Conference on Wind Engineering (12ACWE). Seattle, WA, June 16-20, 2013.

“Unmanned aerial vehicle data acquisition for damage investigations in disaster events,” Stuart M. Adams, Marc L. Levitan and Carol J. Friedland, ATC & SEI Advances in Hurricane Engineering Conference. Miami, Florida, October 24-26, 2012.

“Development of a loss-consistent wind and flood damage scale for residential buildings,” Friedland, C.J. and M.L. Levitan. Proceedings, *Solutions to Coastal Disasters 2011*. Anchorage, AK: American Society of Civil Engineers.

“Integrated Aerial-Based and Ground-Based Damage Assessment of Single Family Dwellings at the Neighborhood and Per-Building Spatial Scales,” Carol J. Friedland, Carol C. Massarra, and Earl Henderson, *9th International Workshop on Remote Sensing for Disaster Response*, September 14-16, 2011, Stanford University

“A Survey Of Unmanned Aerial Vehicle (UAV) Usage For Imagery Collection In Disaster Research And Management,” Stuart M. Adams and Carol J. Friedland, Proceedings, *9th International Workshop on Remote Sensing for Disaster Response*, September 14-16, 2011, Stanford University

“Unmanned aerial vehicle data acquisition for damage assessment in hurricane events,” Adams, S.M., C.J. Friedland, and M.L. Levitan. Proceedings, *8th International Workshop on Remote Sensing for Disaster Management*. 2010. Tokyo, Japan.

“An algorithm predicting building rooftop displacement on aerial photos using 3D rooftop model and exterior orientation properties,” Yang, Y. and C.J. Friedland. Proceedings, *ASPRS 2010 Annual Conference - Opportunities for Emerging Geospatial Technologies*. 2010. San Diego, CA.

“Visual rule-based classification of combined wind and surge hurricane data for residential buildings,” Friedland, C.J., B.J. Adams, and M.L. Levitan. Proceedings, *Seventh International Workshop on Remote Sensing for Post-Disaster Response*. 2009. Austin, TX.

“Residential building damage from hurricane storm surge: proposed methodologies to describe, assess and model building damage,” Friedland, C.J. May, 2009, Louisiana State University: Baton Rouge, LA. p. 214 p.

“Loss-consistent categorization of hurricane wind and storm surge damage for residential structures,” Friedland, C. and M. Levitan. Proceedings, *11th Americas Conference on Wind Engineering*. 2009. San Juan, Puerto Rico: American Association for Wind Engineering.

“Modeling performance of residential wood frame structures subjected to hurricane storm surge,” Friedland, C.J., A.M. Okeil, and M.L. Levitan. Proceedings, *Structures Congress 2009*. Austin, TX: American Society of Civil Engineers.

“Development of a hurricane storm surge damage model for residential structures,” Friedland, C.J., M.L. Levitan, and B.J. Adams. Proceedings, *Solutions to Coastal Disasters 2008*. Oahu, Hawaii: American Society of Civil Engineers.

“Suitability of remote sensing per-building damage assessment of residential buildings subjected to hurricane storm surge,” Friedland, C.J., B.J. Adams, and M.L. Levitan. Proceedings, *Sixth International Workshop on Remote Sensing for Post-Disaster Response*. 2008. Pavia, Italy.

“Remote sensing and field reconnaissance for rapid damage detection in Hurricane Katrina,” Womble, J.A., B.J. Adams, S. Ghosh, and C.J. Friedland. Proceedings, *ASCE Structures Congress 2008*. Vancouver, Canada: American Society of Civil Engineers.

“Remote sensing classification of hurricane storm surge structural damage,” Friedland, C.J., B.J. Adams, and M.L. Levitan. Proceedings, *ASCE Structures Congress 2007*. Long Beach, CA: American Society of Civil Engineers.

“Results of neighborhood level analysis of structural storm surge damage to residential structures,” Friedland, C.J., B.J. Adams, and M.L. Levitan. Proceedings, *Fifth International Workshop on Remote Sensing for Post-Disaster Response*. 2007. Washington, DC.

“A hydrologic flood forecasting system for Mesoamerica,” Villalobos-Enciso, J.E. and C. Friedland. Proceedings, *32nd International Symposium on Remote Sensing of Environment*. 2007. San José, Costa Rica.

“Deployment of remote sensing technology for multi-hazard post-Katrina damage assessment,” Ghosh, S., B.J. Adams, J.A. Womble, C. Friedland, and R.T. Eguchi. Proceedings, *The 2nd International Conference on Urban Disaster Reduction*. 2007. Taipei, Taiwan.

“Deployment of remote sensing technology for multi-hazard post-Katrina damage assessment within a spatially-tiered reconnaissance framework,” Adams, B.J., J.A. Womble, S. Ghosh, and C. Friedland. Proceedings, *Fourth International Workshop on Remote Sensing for Post Disaster Response*. 2006. Cambridge, UK.

“Remote sensing and advanced technology for estimating post-hurricane structural storm surge damage,” Friedland, C.J., B.J. Adams, and M.L. Levitan. Proceedings, *Fourth International Workshop on Remote Sensing for Post-Disaster Response*. 2006. Cambridge, UK.

“Hurricane public health research and Katrina search and rescue mapping,” Peele, R.H., S.A. Binselam, K. Streva, I.L. van Heerden, J. Snead, D. Braud, E. Boyd, H. Brecht, R. Paulsell, and C. Friedland. Proceedings, *2006 ESRI Health GIS Conference*. 2006. Denver, CO.

“Development of vulnerability functions for industrial/petrochemical facilites due to extreme winds and hurricanes,” Hill, C. and M. Levitan. Proceedings, *Solutions to Coastal Disasters 2005*. Charleston, SC: American Society of Civil Engineers.

“Design and suitability of shelters of last resort for remote areas,” Hill, C., M. Levitan, D. Fratta, and I. van Heerden. Proceedings, *10th Americas Conference on Wind Engineering*. 2005. Baton Rouge, LA: American Association for Wind Engineering.

Narges Pourghasemi

Mobile: 949-300-5159 npghasemi@yahoo.com Lake Forest, CA 92609

Sr. Software Engineer / Software Consultant

A versatile and result-oriented Software Developer professional with expertise in System Analysis, Design, Development and Product Enhancement. Over 20 years of consistently proven success, designing and developing Software (full SDLC practice) for E-commerce, web applications, Distributive systems, GUI, animation and Embedded Systems.

Equally effective working alone or in teams; Excellent Customer-Interface skills; Distinguished academic and teaching experience. Proven ability to quickly grasp new challenges, master new technologies and achieve tangible results.

US Citizen.

Industries: Cloud, Enterprise Software, SaaS, Aerospace, Air travel, Flight Entertainment, Automotive, Insurance, Financial, Entertainment, Natural Language Processing, Medical Devices, IT Audit and International enterprises.

Technical Proficiencies

Languages / Frameworks	**Java, Spring WS, MVC, hibernate, EJB/ Java Beans, JPA, Deltaspike, Java Servlets, Java Swing, JavaScript, C/C++, JSP, ASP, HTML, XML/XSL, CSS, Ajax, Python, PERL, PHP, Velocity, X11/Motif, OpenGL, LISP, FORTRAN, Assembly, Groovy, UNIX Shell Scripts (ksh, csh, bsh, FreeBSD), awk, sed, MySQL, JDBC, Oracle 11, SQL, DB2, iBatis/MyBatis, ETL.**
Operating Environments	Java EE Platform, UNIX, Linux, LAMP, Timesys Embedded Linux, ARM, AIX, HP-UX, Mac OS , X-Window, Xcode VMS, VOS, IRIX, SUN, IBM AS400/i-series, IBM RISC, MS Windows, GDS/CRS, Apache Tomcat, Websphere, Jboss 7, WildFly, Agile Scrum.
Communications	HTTP, X.25, MATIP, EDIFACT, FTP, TCP/IP and Sockets.
Tools/Utilities	IDE (Eclipse, Net Beans, JBoss Studio, MS Visual Studio, IntelliJ,Xcode); GUI Builders (Builder Xcessory, UIM/X); SCM(Rational ClearCase/ClearRequest, Visual SourceSafe, AccuRev, CVS, SVN, Maven); Debuggers (xde, dbx, gdb, xdb), AC3D, GIMP, PhotoShop CS4 SDK, vi, Emacs, WebEX, Visio, UML, VMware, SoapUI.

EXPERIENCE

IMIS Consulting Group, Arlington, VA 2014 – Present

Advisory Board Member & Sr. Consultant – Provide information and materials, and make recommendations on project structure, effective planning, policies and assortment of technology. Assisting on Data integration projects.

MERCURY TECHNOLOGY GROUP, Irvine, CA Feb 2015- Oct 2016

Senior Java EE Web Application Developer- Solutions– Design, development, testing and system application support for a new Web Portal application system in support of company’s cloud services infrastructure and customer offerings. The portal system managed client service tickets using emails based on the Notify ticketing system that was maintained in an Oracle 11g. The system was integrated on Window/Linux environment platform. The middle tier business layer was SpringMVC based written in Java.
Environment: Java EE platform, Spring Web Services, MVC, hibernate, EJB/ Java Beans, JPA, SOAP, WSDL, RESTful, Apache Deltaspike, Tomcat, JBoss 7, WildFly, Oracle 11, SQL, Maven, SVN, Linux, Eclipse, SoapUI, SVN.

SOLERA HOLDINGS INC. (formerly DST), Lake Forest, CA 2011- Oct 2014

e-Commerce Application Developer (Java EE Web Services Developer) – Development, Enhancement, basic project management, and updating assortment of eCommerce Enterprise Web Applications for the Aftermarket Automotive Industry, using Java, IBM DB2/SQL, SOAP/REST. Integration of in-house and 3rd party web services, application, Catalog providers and Electronic Data, i.e, EPICOR (formerly Activant), MOTOR FleetCross, ADP Dealer Services, and ACDelco OE. GUI design, and software technical documentation.
Environment: Java, Java EE platform,Web Services, Servlets, SOAP, WSDL, RESTful, AXIS, Apache Tomcat, WebSphere, JAXB, JDBC, IBM DB2, SQL, MyBatis (iBATIS), IBM iSeries(AS400), XML/XSD, Myeclipse, SoapUI, SVN, FTP, HTTP, Linux, PHP.

Independent Software Consultant **2004 – Present**

APPLIED INSURANCE RESEARCH (AIR WORLDWIDE CO.), Boston, MA (2006-2008, 2010, 2012, 2016, 2018)

IT Auditor (Independent Consultant)– Peer Review of the software and the development process of the Hurricane Insurance Model written in C++ & Fortran. The intent of review is to ensure that not only the application development process follows the current industry-standard software engineering practices, but also it complies with the software standards and requirements established by the Florida Commission on Hurricane Loss Projection Methodology as well. Interviewed with all involved IT and modeling group's manager or proxy to discuss and review the process. Provided recommendations for improvements in implementation and documentations, which some of them incorporated into Florida Hurricane Commissions Standards .

THE WALT DISNEY TELEVISION ANIMATION – Glendale, CA (2010)

Software Consultant- Implemented assortment of tools including: Writing a script in Python to execute commands on the specified hostname (remote shell) with some security measurements. Writing Photoshop plug-ins for formatting in different color space. Researched for Parallelism of Video encoding.
Environment: Mac OS 6, Window 7, MS Visual Studio, C/C++, Python, Shell scripts, Linux, Sockets, Photoshop CS4 SDK and plug-in.

TANDEM DIABETES CARE – San Diego, CA (2009-2010)

Software/Firmware Consultant - Developed scripts in Lisp to test embedded system medical devices. This tool used for Hardware testing using Emacs on Mac OS X; and the Firmware was written in C.

Freelance Software/Web Developer - Orange County, CA (2008-2009, 2011)

Design and Development of Websites and Marketing solutions for assortment of Professionals and Services, including Architectural Firm, Dental offices.

CHARLES RIVER ANALYTICS, INC. , Cambridge, MA (2006)

Designed and implemented a Graphical User Interface of an editor for the emulator data exploited in a Context-driven Infospace Configuration for Air Force Research Lab, using **Java Swing**, XML. Wrote the User Manual for this tool; and reformatted other tools documentations into the User Manuals. Research and Analysis of using B-Net for the application.

KAYAK, Concord, MA (2005)

Assisted in development of *Internet Travel Product,* for a travel meta-search company, using Java, J2EE/Tomcat/Struts, extensive HTTP Protocols, XML/DOM/SOAP/AXIS/WSDL, AJAX, Velocity, PHP, HTML, MySQL, CVS, Mac OS X.

TAXWARE, Salem, MA. (2004–2005)

Ported the Tax Management application from SUN Solaris to AIX and Linux platforms. Enhanced, optimized and fixed software defects of the application's front-end.
Environment: X/Motif, Builder Xcessory GUI builder, C on variety of Unix/Linux platforms.

IMS COMPANY, Brea, CA 2011

Sr. Software Engineer – Development of an application for Acceptance Testing Procedure, Performance Verification and Environmental Stress testing of Hardware parts used for a portable in-flight entertainment embedded device.
Environment: C++, Linux/ Ubuntu, SVN, ARM, VMware, Curses, Eclipse, UML, Timesys Embedded Linux, Agile.

LANGUAGE WEAVER, Los Angeles, CA 2009

Sr. Software Developer in Test - Designed and Developed stress and performance tools for software testing and quality assurance including a multithread test tool for REST based application in Java and scripts in Perl, Groovy and Ruby.
Environment: J2EE, Java, Mod Perl, Ruby, Groovy, Linux, VM, SVN, Agile, SCRUM.

DIGITAL RIVER, Eden Prairie, MN /Aliso Viejo, CA 2008

Principal Software Engineer – Designed and Developed the web application User interface for a middle tier management service for complex business services in multi-data center, clustered environment, transparent remoting, service oriented architecture and plugins framework.
Environment: J2EE, Java, JavaScript, XHTML/CSS, AJAX, Tomcat, CVS.

TALEND, Costa Mesa, CA 2007

Technical Consultant – Combined pre-sale/post-sale and technical consultant for an open source data integration tool. Worked with the business developer teams to manage the technical sales cycle and with the customers and partners to bring the technical expertise. Presented more than 60 WebEx demonstration to the prospective customers.
Environment: Java, PERL, Eclipse RCP, MySql, XML, PHP, Tomcat, ETL, Data Integration, JasperSoft reporting tool.

SITA (formerly EQUANT Application Services), Burlington, MA. 1999-2003

Senior Software Engineer – Advance Travel Solutions- Contributed to various projects for a spectrum of clients in the provision of E-Commerce and On-Net application solutions with focus on global airline and travel. The EDI-Application Gateway is constructed around the industry standard seven-layer model for communication architectures.

Conducted the *Message Switch System* setup for a **$20M contract project** with *CCRA* (*Canada Customs and Revenue Agency)* to provide advanced passenger information on all passengers traveling on in-bound international flights to Canada. On time comple- tion of this work, with high degree of quality, and in the absence of an accountable engineer, helped contribute to a new $4M tar- get achievement for phase one (Message Switch) of the project.

Web application Development: Enhanced the SITA Flight Finder Web Applications for the AirOne (Italian Airline) reservation, for the Canada3000 Airline reservation and in-house utility applications, and for SITA Air Cargo Carriers. *Environment*: ASP, JSP, HTML CSS, **Java**, J2SE, Java Servlets, **MVC**, Java Beans, JavaScript , MySQL, JDBC, PERL.

Enhanced communication interface of the SITA Interline Through Check-In (ITCI) system, Air Faring and E-Ticketing Interfaces, to support EDIFACT interchange.

Improved the message exchange interfaces between Amadeus CRS and SITA host servers using the MATIP (Mapping of Airline Traffic over IP) protocol for Type A (Conversational, Host to Host) and Type B traffics.

Wrote utility programs to allow batch files to work under different operating systems after porting the base model and test suite from Stratus/VOS to UNIX;

Assisted for development of a Gateway system to be used to bridge the Canada3000 Tour Operator sales into SITA’s Gabriel CRS (Computer Reservation Systems) for centralized inventory control.

Initiated porting, the complex source base which included the application and the operating environment, from RISC platform to SUN Solaris. Conformed the updated Software Environment and System Configuration;

Rapidly grasped knowledge of the application systems, core products and CRS interfaces, and the company proprietary software development and runtime environment, in a short period of time and was appointed to provide full time support to a major client, Carlson Wagonlit Travel. Served as a consultant; assisted in work estimate, enhancements, for American Express.

- Provided consultant services and developed constant enhancements to the APIs and CRS Gateways based on customer requests and CRS changes.
- Interfaced with Client staff to determine change/enhancement requirements.
- Coordinated all work and frequent releases. Provided written release notes; ensured on time releases.
- Maintained API documentation, and handled writing procedures for support of system and status reports.
- Worked on several projects concurrently and communicated with cross functional teams located in Atlanta and UK.

Environment: *Proprietary Software Environment,* C *based and Scripting Proprietary Languages*, C, NT 4.0, X.25, MATIP, TYPE A/B *messages*, TCP/IP, SUN Solaris, VOS/Stratus, PERL and MS Visual Studio, Source Safe.

U.F.A. INC., Woburn, MA. 1994 -1999

Senior Software Engineer – Involved in all phases of software development and GUI Design for simulation and modeling of an air traffic management system on a distributed system.

Responsible for Data Preparation component for the major client, DFS (Germany’s Federal Aviation Administration). Involved in design and development/enhancement of graphical editors and support tools.

Created a library from scattered codes for the graphical display of radar geographical backgrounds. The creation of this library, subsequently used in the Situation Display and all Data Preparation applications, made code enhancement much easier.

Designed and developed tools for data extraction and conversion from large external data sources: Jeppesen Sanderson navigation database and ICAO FPL recorded Flight Plans database.

Designed and developed the Graphical User Interfaces (GUI) for Data Preparation utilities.

Evaluated and used the COTS GUI builder (UIM/X) for prototyping and development.

Designed and developed Radar Message Filter Editor, an X Window/GUI based tool, for the Raytheon Company.

Consulted in pre-sales activities, scheduling, time/cost estimation, and all Software and User specifications issues.

Environment: C, IBM RISC 6000, UNIX, X11/Motif, UIM/X, ClearCase, DSEE, TCP/IP, Sockets, SGI, SUN, Apollo.

EDUCATION

NORTHEASTERN UNIVERSITY- Boston, M.A. 2004-2005

Ph.D. Candidate (ABD) in Computer System Engineering, Industrial Eng. Dept.
Area of Concentration: Software Engineering, User Interface Design/Human factor (User adaptive interfaces).

GEORGE WASHINGTON UNIVERSITY - Washington, D.C.

Professional Degree in Engineering; Computer Science/Artificial intelligence; minor in Medical Engineering.

UNIVERSITY OF NEW HAMPSHIRE - Durham, N.H., M.S. in Computer Science ***(Artificial intelligence)***

UNIVERSITY OF TEHRAN, B.S. in Computer Science and Mathematics.

Microsoft Windows Embedded Certificate: **Developing Embedded Solutions for Windows XP Embedded.**

Appendix 8: Model Evaluation

Model Evaluation by Dr. Carol Friedland, P.E., Ph.D., C.F.M.

2019 Vulnerability Standards

External Reviewer Comments

AIR's 2019 Vulnerability Standard submission has been reviewed. The following sections provide reviewer comments for each standard and disclosure.

V-1 Derivation of Building Vulnerability Functions

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

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

> Vulnerability functions and their associated uncertainties within the AIR 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 derivation and application of building hurricane vulnerability functions.

> The AIR Hurricane Model for the U.S. includes 34 vulnerability functions based on primary construction material (e.g., wood frame, masonry veneer – detailed in Disclosure V.1.6) 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 story, 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. Other construction characteristics are addressed through the Individual Risk Module.

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

The AIR 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 AIR 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 AIR 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 AIR Hurricane Model for the U.S.

Disclosures

1. Describe any modifications to the building vulnerability component in the hurricane model since the previously accepted hurricane model.

The building vulnerability component of the AIR Hurricane Model for the U.S. addresses four key updates. Three of these updates address temporal factors to make the model relevant to 2020, 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 derived and implemented.

Figure 28 of AIR's V-1 response shows the process by which the vulnerability functions were derived and implemented. The flowchart shows how published research, engineering expertise, and results of damage surveys are combined to create the 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 actual insurance claims data used to develop the building hurricane vulnerability functions. Describe in detail what is included, such as, 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.

AIR 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. AIR has received detailed data covering more than $2.5 trillion of personal, $6 billion of manufactured homes, and $75 billion of commercial residential exposure.

4. Describe any new insurance claims datasets collected since the previously-accepted hurricane model.

Since the previously-accepted hurricane model, AIR has obtained industry insured loss estimates from Verisk's Property and Claims Services for 2017 and 2018 hurricanes impacting Florida based on business line: personal, commercial, automobile. These data are generally at the state level or, for more significant events such as 2017 Hurricane Irma and 2018 Hurricane Michael, at the county level.

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

The vulnerability functions are based on engineering analysis, post-event damage surveys, expert consultation, and analysis of claims and industry loss data. In addition to the academic and industry background of AIR's engineering team, assessment of peer-reviewed literature and input from external reviewers ensure reasonable results.

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

AIR 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 2012, 2015, 2017, and 2018. In addition, AIR 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.

7. 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. Provide the total number of building hurricane vulnerability functions available for use in the hurricane model for personal and commercial residential classifications.

Vulnerability functions are included in the AIR 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.

8. 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, AIR has identified 11 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.

9. Describe the relationship between building structure and appurtenant structure hurricane vulnerability functions and their consistency with insurance 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 claims data, published research, and damage surveys when possible.

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

1. ***residential construction types are unknown, or***
2. ***one or more primary building hurricane characteristics are unknown, or***
3. ***one or more secondary characteristics are known, or***
4. ***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.

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

The AIR 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.

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

The AIR 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 AIR 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.

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

The AIR 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.

14. Provide a completed Form V-1, One Hypothetical Event. Provide a link to the location of the form here.

See the section entitled Form V-1, One Hypothetical Event for reviewer comments.

V-2 Derivation of Contents Hurricane Vulnerability Functions

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

The vulnerability functions for contents in the AIR 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. AIR 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 AIR 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. Describe any modifications to the contents vulnerability component in the hurricane model since the previously accepted hurricane model.

No changes are reported for the AIR Hurricane Model for the U.S. contents vulnerability components related to wind hazards since the previously accepted model.

2. Provide a flow chart documenting the process by which the contents hurricane vulnerability functions are derived 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 (including insurance claims data), methods, and processes used to develop and validate 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. AIR 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. 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.

5. Describe the relationship between building structure 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.

V-3 Derivation of Time Element Hurricane Vulnerability Functions

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

Time element vulnerability functions in the AIR 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. AIR 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 historical data.

Based on a review of a scatterplot provided by AIR 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 derivations 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 used by the hurricane model shall include time element hurricane losses associated with wind, missile impact and flood (including hurricane storm surge) and 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. Describe any modifications to the time element vulnerability component in the hurricane model since the previously-accepted hurricane model.

No changes are reported to the time element vulnerability component since the previously accepted hurricane model.

2. Provide a flowchart documenting the process by which the time element hurricane vulnerability functions are derived and implemented.

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 and validate 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.

AIR 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 how time element hurricane vulnerability functions take into consideration the damage (including damage due to flood (including hurricane storm surge), and wind) to local and regional infrastructure.

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, validation. The AIR Hurricane Model for the U.S. does not explicitly estimate losses from precipitation induced flood damage.

5. 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 their associated uncertainties shall be theoretically sound and consistent with fundamental engineering principles. These measures shall include fixtures or construction techniques that affect the performance of the building and the damage to contents and shall consider:

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

AIR'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 AIR 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 AIR 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. Describe any modifications to mitigation measures in the model since the previously accepted model.

Since the previously accepted hurricane model, a temporal modification has been made to make the model relevant to 2020: defaulting of the "roof year built" secondary risk feature to a new roof for buildings less than ten years old has been updated. Additionally, roof age assignment has been updated to classify buildings built 10 to 20 years ago as having an “average” roof year built when the roof year built is unknown.

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 previously-accepted hurricane model.

The Individual Risk Module is used to calculate the impact of hurricane mitigation measures and secondary characteristics. This module has been updated as described in Disclosure V-4.1 for roof year built.

3. Provide a completed Form V-2, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage. 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, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage.

The mitigation measures listed in Table 14 of AIR’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 AIR’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 AIR 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. AIR’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 AIR 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-3.4. 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-3.4. 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 hurricane mitigation measures and secondary characteristics affect the uncertainty of the vulnerability. Identify any assumptions.

AIR 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.

9. Provide a completed Form V-3, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), 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.

10. Provide a completed Form V-4, Differences in Hurricane Mitigation Measures and Secondary Characteristics. 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.

11. Provide a completed Form V-5, Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), 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 "FormV1Input19.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 shall 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 AIR 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 AIR for the current Form V-1 submission are 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, AIR 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. If additional assumptions are necessary to complete this form (for example, regarding structural characteristics, duration, or surface roughness), provide the reasons why the assumptions were necessary as well as a detailed description of how they were included.

The AIR 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, AIR has assumed a hypothetical event of 1-hour duration, which is a different assumption than in previous submissions. Additionally, the AIR Hurricane Model for the U.S. considers actual terrain surface roughness to calculate the wind speeds used in 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.

Plotted Estimated Damage/Subject Exposure plots are reasonable for the reference structures and wind speeds of 1-hour duration.

D. Include Form V-1, One Hypothetical Event, 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. 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, 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 relative effectiveness of different hurricane mitigation measures with wind speed is presented in the tables of AIR's Form V-2 response. Form V-2 reports relative changes in mean damage ratio, which can be difficult to interpret. Therefore, Form V-3 for the current and previous submission were reviewed and were found to reflect relatively minor changes in mean damage ratios, which is reasonable.

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.

B. If additional assumptions are necessary to complete this form (for example, regarding duration or surface roughness), provide the rationale for the assumptions as well as a detailed description of how they are included.

The AIR Hurricane Model for the U.S. requires a sustained (one-minute) wind speed time profile to calculate damage ratios. Therefore, a set of events were created to approximate the wind speeds at the specified locations. Duration effects were not accounted for in the response to V-2.

C. 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, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage, 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, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret item) 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, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret item) 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. If additional assumptions are necessary to complete this Form (for example, regarding duration or surface roughness), provide the rationale for the assumptions as well as a detailed description of how they are included.

The AIR Hurricane Model for the U.S. requires a sustained (one-minute) wind speed time profile to calculate damage ratios. Duration effects were not accounted for in the response to V-3.

D. 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, as discussed in the review of Form V-3.A.

E. 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. Also include Form V-3, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), in a submission appendix.

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, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage, relative to the equivalent data compiled from the previously-accepted hurricane model.

Values provided by AIR in Form V-4 were visually reviewed and found to agree with differences from the previous Form V-2 submission.

B. Provide a list and describe any assumptions made to complete this form.

Please see the review of Form V-2.B.

C. Provide a summary description of the differences.

The differences are not substantive, with the maximum difference of 1.5%.

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, Differences in Hurricane Mitigation Measures and Secondary Characteristics, 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, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), relative to the equivalent data compiled from the previously-accepted hurricane model.

Values provided by AIR in Form V-5 have been confirmed through reviewer calculation of Form V-3 data for the previous and current submission.

B. Provide a list and describe any assumptions made to complete this form.

Please see the review for Form V-3.C.

C. Provide a summary description of the differences.

Moderate differences are shown on Form V-5, most notably at 135 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. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name. Also include Form V-5, Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), in a submission appendix.

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, 2019 by the Florida Commission on Hurricane Loss Projection Methodology has been reviewed. The information submitted by AIR Worldwide in response to this document has been reviewed in detail for each of the standards and disclosures. A summary of AIR's response and evaluation of the approach has been provided by the reviewer.

Based on this review, AIR's response appears thorough and complete. The vulnerability functions within the AIR 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 historical insurance claims data. The AIR 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 19, 2020

Model Evaluation by Narges Pourghasemi

A Peer Review of AIR Hurricane Model for the U.S. (M521 version 1.0.0) as implemented in Touchstone ® 2020

Touchstone® is a product of AIR Worldwide

Narges Pourghasemi
Independent Information Technology Auditor

September 22-25, 2020

Overview

This document summarizes the peer review I conducted in September of 2020 for AIR Worldwide's implementation of their AIR Hurricane Model for the U.S. within the Touchstone® software. The intent of the review is to ensure that not only the application development process follows the current industry-standard software engineering practices but also it complies with the software standards and requirements established by the Florida Commission on Hurricane Loss Projection Methodology as well. This year the audit performed via Microsoft Teams Meeting for presentations, interviewing staff and reviewing the documents remotely due to Covid-19 pandemics restrictions.

Findings of the Peer Review

This review is based on AIR's Touchstone® 2020 version and Model 521 version 1.0.0. This year audit sessions were under different circumstances than previous years and carried out by audio/visual screen share only. There was no access to any documents or code, yet the substantiated documents were presented trough MS Teams Meeting.

The focus of the audit process was mostly on new enhancements. This year, AIR changed the internal model number from M21 to M521 and restarted the version from 1.0.0. The reason for this Model replacement was that to separate the code base of the model to be used for ratemaking in the state of Florida. The original M21 includes precipitation-induced flood as of Touchstone 8.0, and cannot be used for ratemaking in the state of Florida. M521 continues as before with the wind and storm-surge perils.

The findings are grouped according to the seven computer standards established by the Florida Commission on Hurricane Loss Projection Methodology as of November 2019. The following personnel or proxies from the following groups were presented during the audit: documentation, Product Management, Research & Modeling, Meteorology, Software Development Group, Database group, Release Engineer, Quality Assurance and IT/Security personnel, and Client Services Group, who demonstrated their knowledge of the pertinent subjects. In this interview process, the requirements for all sections C1-C7 of the Florida Commission's standards were discussed and reviewed with the personnel of each group, via Microsoft Teams Meeting.

Standard CI-1: Hurricane Model Documentation

AIR Worldwide maintains a central document management and repository *AIRPort*, which is a SharePoint repository, for both internal user and external clients documentations. *Microsoft Teams* provides an interface for accessing the SharePoint repository.

The documentations are created separately from the source code and stored in the repository which easily accessible online by all staff and designate external client users. During entire audit process, AIR personnel were utilizing this *AIRPort* repository to present the software documentations, requirements, software design and implementation, test procedures and plans, code guidelines and IT policy. All the documents for all section or group consist of a revision history, author, approver, and table of contents.

Software and model-related documentation is generated and maintained by each of these groups: Software Documentation, Research, Modeling, Software Development, Client Services, Security, Support and Quality Assurance. It is verified that each of these groups reviewed and signed out the documentation for each version as indicated in the document version history. Touchstone® has also an online Help system that is accessible from within the software. Help System is a keyword query search and not context-sensitive search, by which a list of pertinent items to the search keywords is provided. There is also a Wiki, which some documentation for user is being stored.

The *"List of All Externally Acquired Hurricane Model Specific Software and Data Assets"* spreadsheet has been reviewed. Per my recommendation, AIR staff added another column for usage status. Some examples of usage status can be if the asset is new, or on-hold for future use.

Enhancements and Florida Commission Documentation Map, which includes version specific updates and enhancements to both Model and Touchstone® was reviewed and verified. This document contains a table that fulfills the Florida Commission requirement from *Section CI-1.D. Computer/Information Standards/Documentation*. This table include a column that itemizes the version-specific changes, and the other columns in this table maps the itemized changes to the pertinent documents in the Computer Standards documentation set C1-C7.

The first set of significant changes were the result of modeling data due to periodical updates from external sources: *Historical* and *stochastic catalogs*, *US Industry Exposure database*, and *ZIP code database*. HURDAT2 re-analysis changes due to inclusion of new historical hurricane events.

Another set of significant changes were building, component and roof age bands to be current as of 2020. This update captures the impact of two years of building and component aging and deterioration since the last model release. Additional related enhancement was the assignment of unknown roof age.

As it mentioned earlier, one structural changes in earlier version of Touchstone was creating a new Model 521 deviated from original Model 21 with the exclusion of precipitation-induced flood module which was added in some point the Model 21.

There were some software enhancements in recent versions of Touchstones. One of these enhancements was updated exposure-weighted grid for disaggregation. Another enhancement was the Min-Max Deductible Policy Logic, which it was discussed and explained by staff.

There were other enhancement items in *Enhancements Table,* which were introduced in the earlier versions of Touchstone®. Some of these earlier Touchstone version enhancements do not impact Florida loss costs or PMLs, but they were listed in the Enhancements table per FCHLPM recommendation. There were no significant formulas or calculation changes this version of Model 521.

Some of these Updates in regard to these changes in the documentation, requirements, data, implementation and testing were discussed. The pertinent C1-C7 Standards were verified for some of these categories, including: documentation, code review, changes history in the source control management tool, requirements, implementation, verification and security.

Standard CI-2: Hurricane Model Requirements

The online central SharePoint repository, *AIRPort*, stores the requirements documentation required for the development of the Model 521 hurricane model as well as Touchstone®. The requirement documents are created for each component and for each software release of Touchstone®, stored and maintained in the document repository.

For the purpose of this Audit, all the requirements document pertinent to the items in *Enhancements* table are viewed. The requirements for newly replacement Model 521 which is incorporated in Touchstone® 2020 included in the *"M521 AIR Hurricane Model for the United States Scope Document for Touchstone 2020*". The motivation and rational for such replacement is explained and any changes are documented.

Requirements for all other enhancements which are incorporated in the Touchstone® 2020 are described in the same document. The requirements pertinent to "roof age" updates and "assignment of unknown roof age" were observed and discussed with staff.

Standard CI-3: Hurricane Model Organization and Component Design

Technical personnel in Research, Modeling, Software Development, and Database groups were present and responded to the questions in regards to the architecture and structure of the enhanced components.

The SharePoint repository provides design documentation for Touchstone and Model M521. A separate Folder for all Flow charts and diagrams were created. There were work on progress to updates some of the existing flowcharts for better depiction of components, functional and logical connectivity and interaction. Some of these enhancements include new symbols and illustration of parallel processing of some components. In addition there exist a spreadsheet for flowchart tracking which listed all flowchart files and their description.

The design document which is referenced by *"Touchstone 2020 Design Document - M521 AIR Hurricane Model for the United States"* link in the enhancement table was briefly reviewed. This was the main document for the latest version of the platform and the Model. Also the flowcharts in two part documents "*Model 521 Porting and Implementation in Touchstone"* which illustrated the workflow among different group was presented in the audit session.

The AIR development staff briefly discussed the Engine and Model interface and how these components are communicated to each other. Related diagrams and documentation for IModel interface was presented.

The design documentation and flowchart associated with the some items in the Enhancement table were reviewed as well. The two new set of 50k and 100K US Hurricane as of 2020 in the document were reviewed and discussed.

AIR hurricane Model is implemented on a single Touchstone platform.

The Network organization was depicted as diagrams in Touchstone System Tires and being reviewed.

Standard CI-4: Hurricane Model Implementation

Developers in Research, Modeling, and Software Development groups were present in the Virtual meeting and discussion was more focused on implementation specifically for the items in Enhancement table. One major structural enhancement in the earlier Version of Touchstone, Touchstone version 8.0, was replacement of the original Model 21 with new derived Model 521, which excludes precipitation-induced flood module. This new Model 521 was inspected in the context of TFS Source control and how these versioning and naming is maintained in TFS.

The updated code snippets for roof age bands and update building and component age as of 2020 was reviewed. Also the code section for Min-Max deductible policy logic was reviewed and discussed. By observing these two new enhanced code, it was advised for better coding styles and adhering to coding standards for better program maintainability, at least for newly created codes by newly joined developers.

One other enhancement is updating internal password controls for communication between the Touchstone application and the SQL Server for fetching data stored in the databases. AIR staff indicated this is a usability enhancement and only from development perspective and not general security.

The programming languages used in development of Model 521 and Touchstone® are: FORTRAN, C++, C# /. NET, SQL, and Java. The coding guidelines have been reviewed as well as sample codes. It is verified that AIR Worldwide maintains the technical documentation, coding standards and guidelines for all the utilized programming languages in the online Document Repository. Nevertheless it was recommended to update those guidelines for missing some coding styles and standards, specifically adding sections and coding style for constants values.

Research and development group were asked to show the codes for new enhancements in C++ and Fortran, and explain these new enhancements. They were also asked to show the history and comparing the new version of the code against previous ones in repository. It was verified sufficient documentation and some comment was provided as well as exception handling. It was advised developer to adhere to coding standards by defining constants for variables whose value is fixed for the duration of the program and utilize it in their program. The developers took the advice and modified the code immediately by defining constants variables for those valued and present it by the end of audit sessions. Also recommended to add more comments in some part of the code.

The Research and Modeling and the Software Development groups use mainly *Microsoft Visual Studio Team Foundation Server (TSF)* for Source control management as well as to track software and documentation change history. The *Microsoft Visual Source Safe (VSS)* still is used for legacy code. During the audit sessions the location and change history of the component in TSF were verified. TFS server version control system provides for comments to be added by the developer each time a change is made and some of those comments for Model 521 were inspected.

The complete documentation set is designed to provide traceability at all levels, including requirements, design, implementation, and verification or testing. All components attributes, i.e. name, creation date, modification date and etc. are being reflected in some source code and definitely in source control repository, TFS.

The development group uses Visual Basic Line-of-Code counter for all its code. The AIR development staff briefly discussed the Engine and Model interface and how these components are communicated to each other. Related diagrams and documentation for iModel interface was presented. They also stated that there were no new equation or Formulas in this version of Touchstone and Model 521. The *Model 521 Equations/Formulas, Variable Mapping, and Crosschecking* document, which discusses the implementation of equations, was presented.

AIR Touchstone runs on a single platform and single Network. It uses the same software stack for each deployment. The hardware, operating system, and essential software requirements are exactly the same for every deployment. The Touchstone Network layout was presented. This Network organization is comprised of client workstations, IIS Application Server, Analysis Manger server, Analysis Engine, database servers, and Model data share. According to AIR staff, Microsoft HPC server as part of Analysis Management Tier, is basically a job manager tool.

Standard CI-5: Hurricane Model Verification

As part of interviews with Research, Modeling and Software Development and QA Groups, the processes for testing and verification of Model 521 and Touchstone® software and data were discussed and reviewed.

It was verified that code for Touchstone®, Model 521 includes statements for error and exception handling as appropriate. The error logging also were discussed.

The overall testing, including user interface and integration testing, is performed using SILK, for automatically verification and comparison. QA staff stated the AIR utilizes 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 are also using *ClearQuest* for issue tracking if something fails.

AIR Worldwide has defined general guidelines for testing the Touchstone®. The Software and Model Testing Procedures provided for different test levels: unit testing, integration testing, Module Interface testing and User Interface testing, as well test types: Installation testing, Smoke test, Acceptance test, and Regression test.

The Test Plans that are developed by QA team are accessible through document repository. A high level QA Test Plans for Touchtone documentation, which include test plans for new enhancements has been reviewed.

The *Model 521 Equations/Formulas, Variable Mapping, and Crosschecki*ng document which contains examples of crosschecking procedures and results for verifying equation was presented during the audit.

The flowchart illustrating Test Process workflow and flowcharts that showing where the validation occurs during the development and implementation processes has been reviewed. Also the Flow charts in two part documents *"Model 521 Porting and Implementation in Touchstone"* illustrate the data validation during several steps of the implementation

QA team explained about Environics analytic used for geospatial validation, and USGC National Land Cover Database for verification.

The verification procedures for new enhancements and version updates were focused for review. QA team displayed the Testing Approach for validation exposure that simulated Min/Max policy deductible scenario. They also showed a test plan and test cases for roof age.

The QA team demonstrated sample test run on Model 521 and showed the test result and its passing/fail status which provided by an email notification.

Standard CI-6: Hurricane Model Maintenance and Revision

AIR Version change management process document in the form of a flowchart was briefly reviewed. The Touchstone® software, model and versioning methodology is documented in *AIRPort*.

Model and Software Revision Policy

A major release of Touchstone® occurs annually. A major release may incorporate new hurricane data from the previous year, improvement in the hurricane model, new user functionality, and possibly new software architecture. Between major releases, AIR Worldwide may releases minor version containing software bug fixes and user functionality enhancements. As of earlier version of Touchstone, Touchstone 8.0 a separate new Model 521 was introduced which was deviated from M21 and started with the version 1.0.0. This new Model 521 was created due to excluding precipitation-induced flood module in the original Model 21.

Source Code, Data and Documentation Maintenance

Microsoft Visual Studio Team Foundation Server (TSF) mostly is used for source control management and to track software and documentation change history. For some Research project or tool, the

Microsoft Visual SourceSafe (VSS) is used. The *TSF* was reviewed in several instances when reviewing the code and structure of the software.

AIR also uses *Microsoft SharePoint* (internally known as *AIRPort*) to manage project, archive and monitor requirements; store and share design plans, and test plans.

The Software Development Group and Research and Modeling group showed some sample of code in and C++ and FORTRAN per request, both in the enhancements and randomly. The code snippets in the enhancements viewed more in detail and recommendation was provided.

Tracking Software and list of model revisions

The tracking tool, *ClearQuest*, is used for all internal clients' ticket, i.e.: project management, logs, defects, revision, enhancement, and change requests assignment tracking. The AIR staff demo this tool in use and the severity feature in the tool per my request.
Salesforce CRM is used for tracking defect, bug, enhancements, and recommendation submitted by clients. The reported defects will be reported and ticketed in *ClearQuest.*

A "version change history" spreadsheet, which includes a list of all model revisions with their dates, as specified in C-6.D of the Computer Standards was presented. A "View Summary Log" option was accessible via a pop up menu.

Standard CI-7: Hurricane Model Security

AIR Worldwide has mandated to comply with its parent company, Verisk Analytics', *Information Security Policy Framework,* enterprise wide definition of fundamental principles for the protection of information resources. AIR *IT* and *Security & Compliance* group works with Verisk Risk & Compliance team to practice and perform these security measures.

The *Information Security Policy Framework* document was reviewed as well as the AIR *IT* and *Security & Compliance* personnel was interviewed. Per this document, designated policy owners of Enterprise Risk & Compliance group review Verisk's information security policies and awareness annually.

Members of AIR *IT* and *Security & Compliance* group, were present during the Audit sessions. They discussed IT Security Management and provided a list of security tools, which comply with Enterprise *Information Security Policy Framework,* and are in various stage of deployment for AIR business. This group also discussed the multi factor authentication, 90 days password change and role based access control. The later restricts network access based on person's role in the organization. They also explained regular security reminders are practiced, as well as security test, like phishing test are exercised. The team reassured that secure FTP servers for obtaining external data sources or internal are used.

The AIR IT and Security team also briefly explained the Emergency Response Team means and process and how the information is secured in safe location in such emergency event. In response to the Covid-19 pandemic question, the AIR IT and Security team, reassured of continuity of all security while staff working remotely.

AIR *Touchstone®* runs on a single platform. The team also presented the *"Touchstone® Installation Guide"* which provides the guidance and practices in user management and access control, anti-virus usage and more.

Areas For Improvement

After observing some of the new code pertinent to items in enhancement table, noticed some coding standards were not practiced consistency, and the coding guidelines needed to be modified to address these coding standards. AIR development took action quickly and modified the code by the end of audit session and they committed to the following actions in future:

- Constitute a recurring training on coding standards for every three months.
- A mandatory training for all the people who would be writing the code.
- Training should cover all programing languages currently being used.

Conclusion

It is my opinion that AIR Worldwide's implementation of Model 521 within Touchstone® is in compliance with the computer standards established by the Florida Commission on Hurricane Loss Projection Methodology. It is also my opinion that the software engineering practices at AIR Worldwide are in accordance with current software industry standards especially with the stipulation of quarterly code reviews.

Appendix 9: Accounting for Secondary Risk Characteristics

Executive Summary

This document provides an overview of AIR'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 AIR Hurricane Model for the U.S. and is included in AIR'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.

AIR'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 AIR Hurricane Model for the U.S. 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. AIR'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 AIR Hurricane Model for the U.S. 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 AIR 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 AIR Hurricane Model for the U.S. 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 60) have been identified as having a significant impact on building damage and losses. Options corresponding to each feature (see Table 66) are identified based on construction practice. Algorithms for modifying the damage functions are developed based on engineering principles and observational data. The AIR Hurricane Model for the U.S. 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 AIR 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 AIR’s development of loss modification factors for a range of building features similar to those used in the Florida public domain study.

Overview of AIR Catastrophe Modeling Technology

Figure 80 illustrates the components of AIR’s catastrophe models. In the case of the AIR Hurricane Model for the U.S., 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.

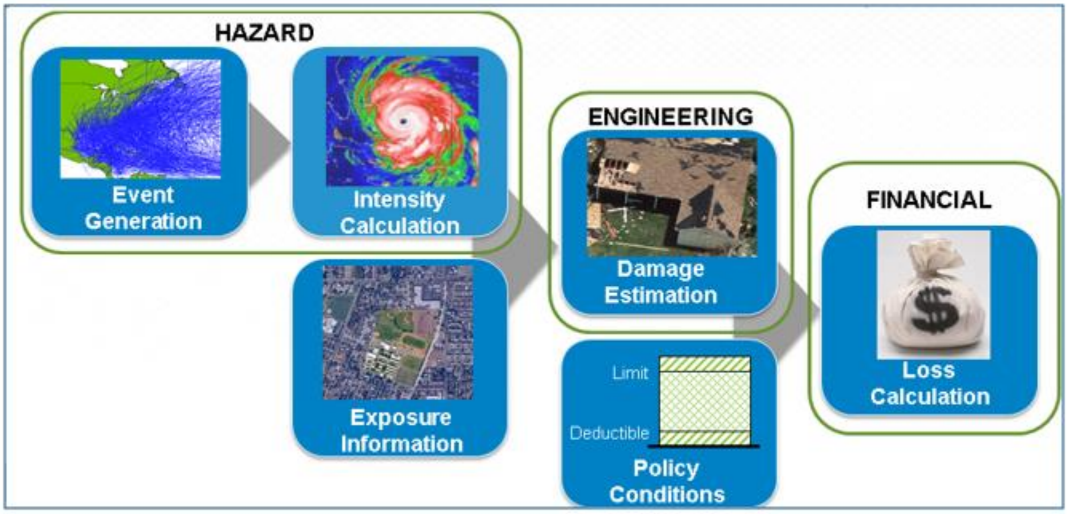


Figure 80. Components of an AIR Catastrophe Model

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 AIR Hurricane Model for the U.S. 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, AIR 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 AIR Hurricane Model for the U.S. 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 AIR 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. AIR 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 81, the model ensures non-zero probabilities of zero and one hundred percent loss (for individual properties).

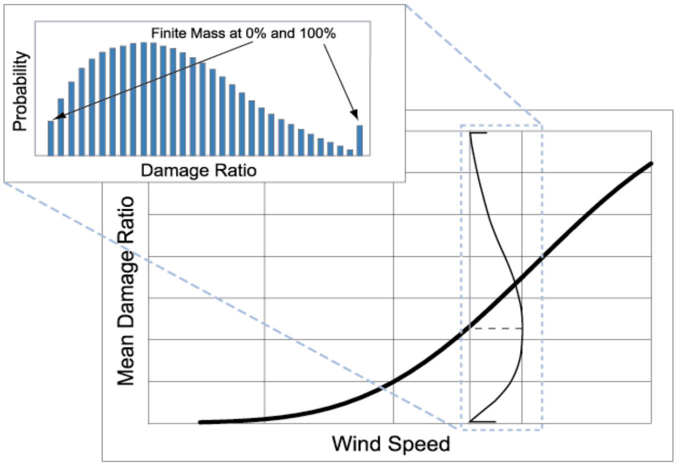


Figure 81. Representative Damage Function

AIR 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, AIR 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 (Figure 82). 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.

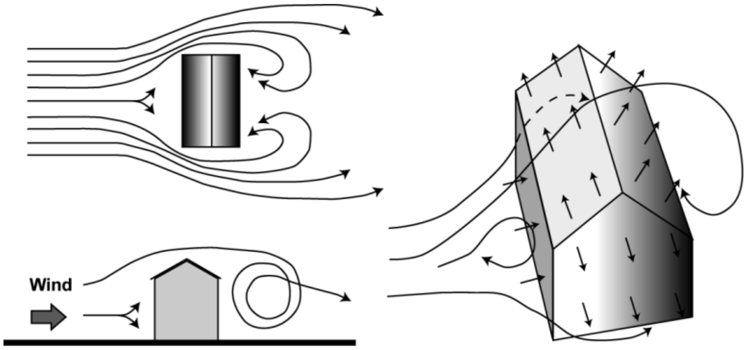


Figure 82. Wind Flow Around Buildings Can Generate Severe Pressure and Suction Forces

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 (Figure 83).

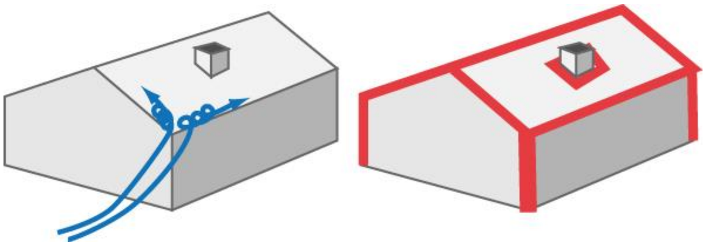


Figure 83. Wind Flow Separation Around Roof

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 84 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 façade (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.

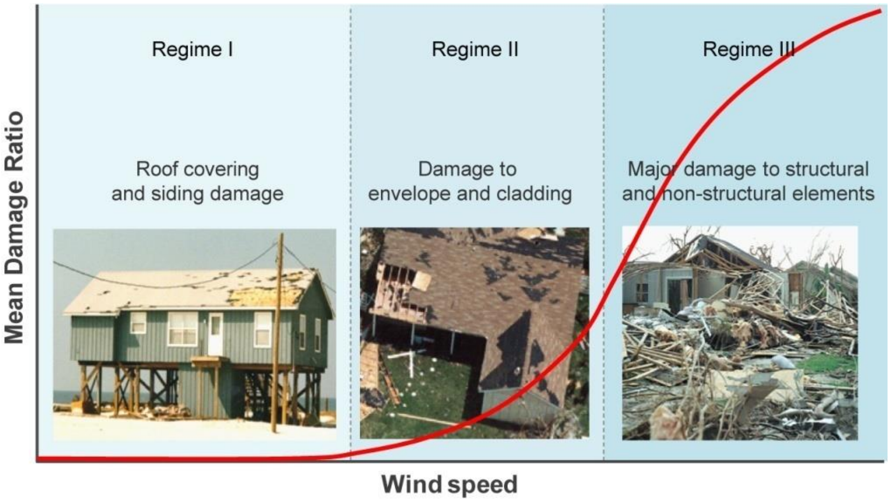


Figure 84. Damage Profile of Non-engineered Buildings

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 a 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 85.

Figure 85. Damage to (a) Mechanical Equipment, (b) Roof, (c) Cladding, and (d) Windows

Building and Environmental Features

AIR accounts for the impact of secondary building and environmental characteristics, or features, on the wind vulnerability of individual risks. The methodology was developed at AIR 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 AIR Hurricane Model for the U.S., 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 AIR Hurricane Model for the U.S. 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.

Figure 86 illustrates the application of modification factors to the basic damage functions.

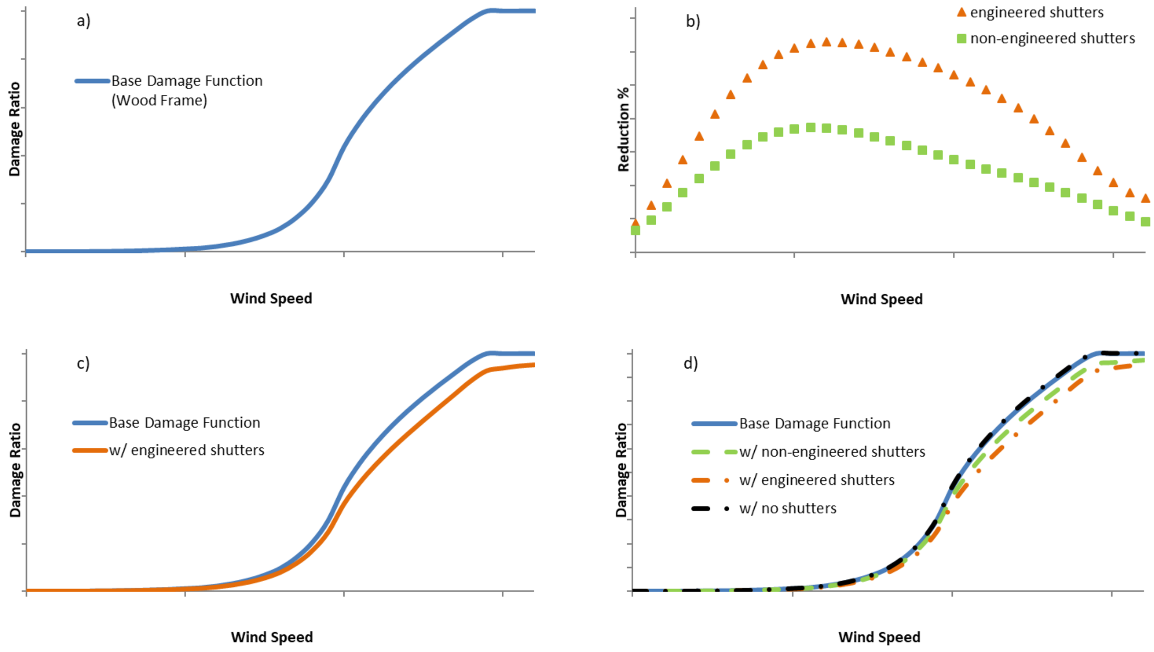


Figure 86. (a) Basic Damage Function for Wood Frame Construction; (b) Reduction in Damage for Engineered vs. Non-Engineered Shutters; (c) Basic Damage Function and Modified Function for Engineered Shutters; (d) Envelope of Damage Functions, All Protection Options

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 AIR Hurricane Model for the U.S. are shown in Table 60. For each of these, various options are available, as discussed below. For the AIR 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 60. Secondary Risk Characteristics Supported by the AIR 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
- Pool enclosure
- Shed
- Masonry boundary wall
- Other fence
- 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 a 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
- Hurricane ties
- Nails/Screws
- Anchor Bolts
- Gravity/Friction
- Adhesive/Epoxy
- Structurally connected

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) Silver Option 1
- Fortified Home™/Business (IBHS) Silver Option 2
- Fortified Home™/Business (IBHS) Gold Option 1
- Fortified Home™/Business (IBHS) Gold Option 1

  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
- Single width doors
- Double width doors
- Reinforced single width doors
- Reinforced double width doors
- Sliding 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)
- 20% to 60%

- Less than 5%
- 5% to 20%
- 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

For builder's risk policies, this secondary feature can be used to identify the phase of construction that is currently underway. If no builder's risk is selected (0), then construction is assumed to be complete and regular risk is applied. Buildings under construction have varying degrees of vulnerability that depend on the construction phase:

- 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
- Overhang/Rake

- Chimneys
- Air conditioning units
- Skylights
- Parapet walls
- Dormers
- Waterproof membrane/fabric
- Secondary water resistance (e.g., bitumen tape)
- 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 membrate 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
- Screws
- Nails/staples
- Adhesive/epoxy
- Mortar

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
- Plywood
- Wood planks
- Particle board/OSB
- Metal deck with insulation board
- Metal deck with concrete
- Pre-cast concrete slabs
- Reinforced concrete slabs
- Light metal

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
- Screws/bolts
- Nails
- Adhesive/epoxy
- Structurally connected
- 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
- Flat
- Gable end without bracing
- Gable end with bracing
- Hip
- Complex
- Stepped
- Shed
- Mansard
- Pyramid
- Gambrel

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
- Reinforced single door garage
- Double 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 AIR Hurricane Model for the U.S. 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

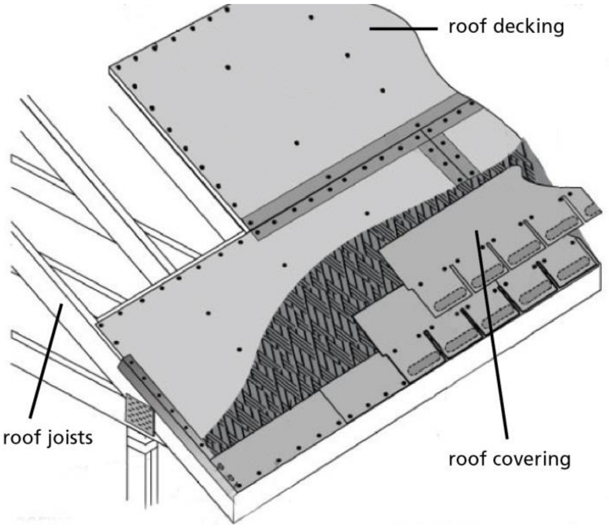


Figure 87. Some Key Components of a Roof System

Brief descriptions of some of the features that influence damageability and loss due to hurricanes are provided below.

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 88 shows typical wind damage to a roof covering.

Figure 88. 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 89 shows wind damage to a roof deck.

Figure 89. 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 90).

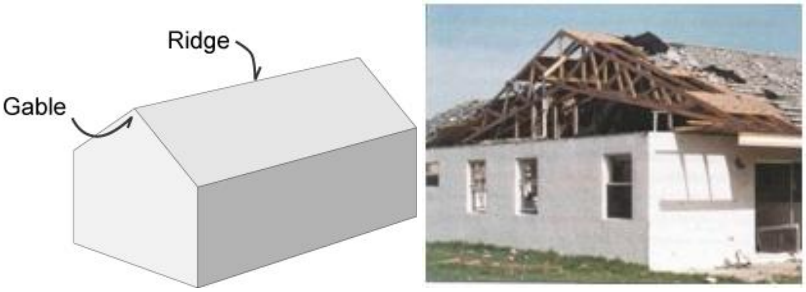


Figure 90. Illustration of a Gable Roof and Hurricane Damage

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 91).

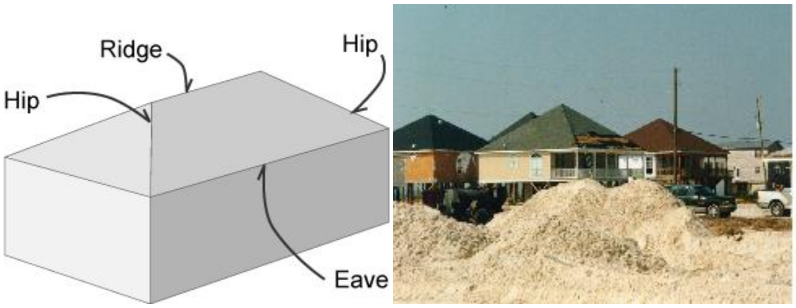


Figure 91. Illustration and Examples of Hip Roofs

Mansard Roof—Like the hip roof, this roof also slopes in four directions but there is a break in each slope (Figure 92).

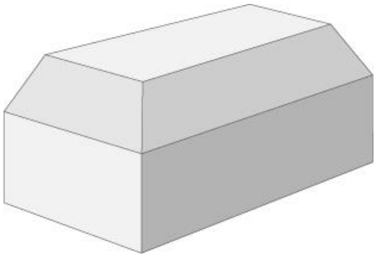


Figure 92. Illustration of a Mansard Roof

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.

AIR’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 1.00, 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 93.

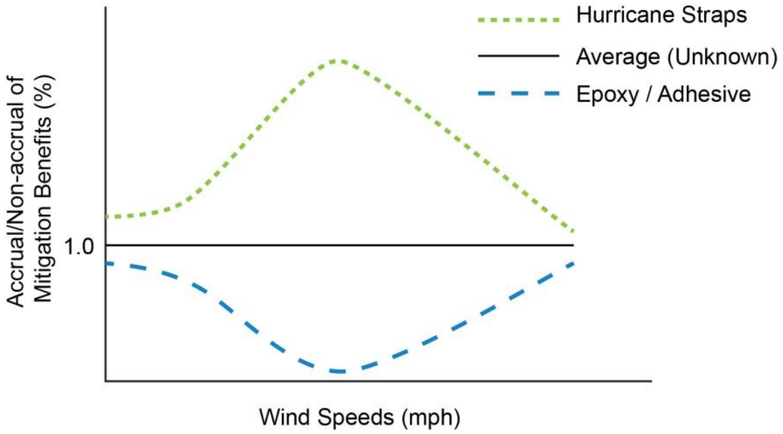


Figure 93. Mitigation Benefits of Various Roof-Wall Anchorage Options

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 94, 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.

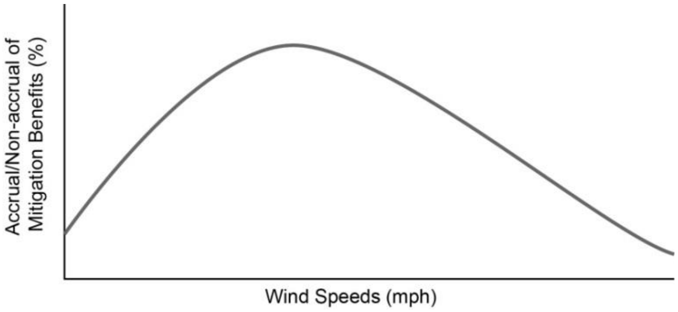


Figure 94. Modification Function for Engineered Storm Shutters

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 95.

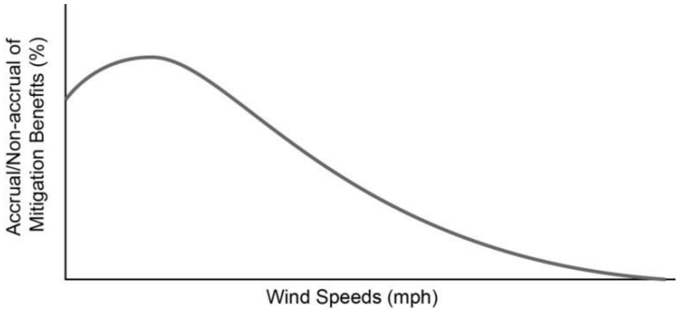


Figure 95. Modification Function for Slate Roofing

Spatial and Temporal Dependency of the Marginal Impact of Secondary Risk Characteristics

For a given construction type, occupancy class, and height, the AIR Hurricane Model for the U.S. 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 was 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. AIR has analyzed this data to validate the impact of individual characteristics and characteristics in combinations. Figure 96 compares modeled and observed mitigating impacts of key individual building characteristics, as well as of the combined characteristics in a single building (mitigated building).

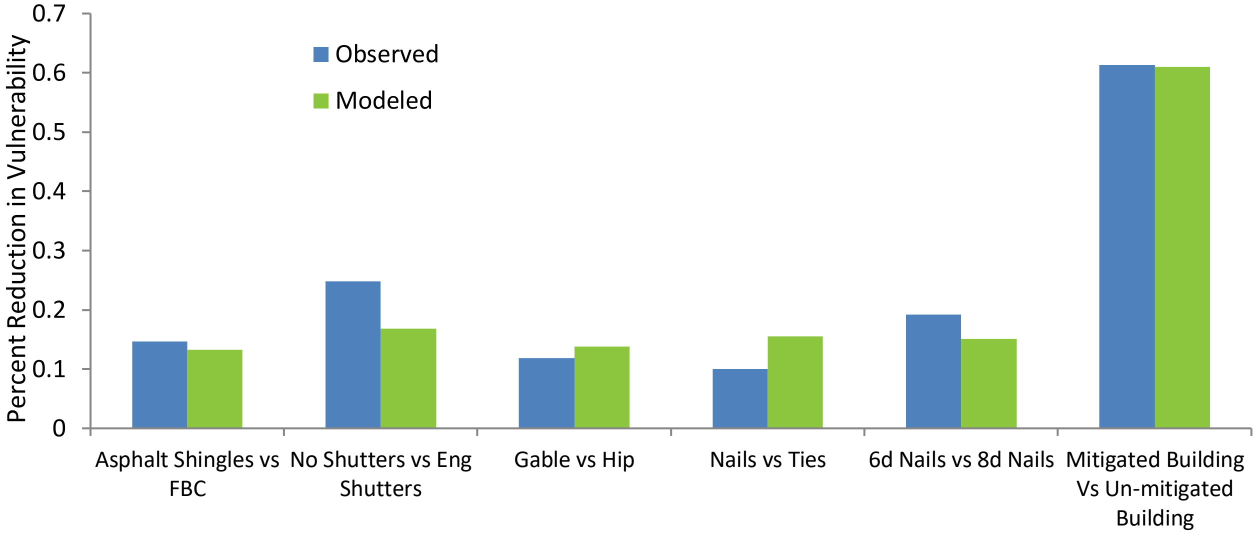


Figure 96. Validation of the Impact of Secondary Risk Characteristics, Alone and in Combination

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 AIR Hurricane Model for the U.S., 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, AIR has identified six unique building categories for Florida, as listed in Table 61, 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 61. 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

*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 97 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 AIR individual risk module that meet the minimum requirements of FBC 2001. For example, AIR 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.

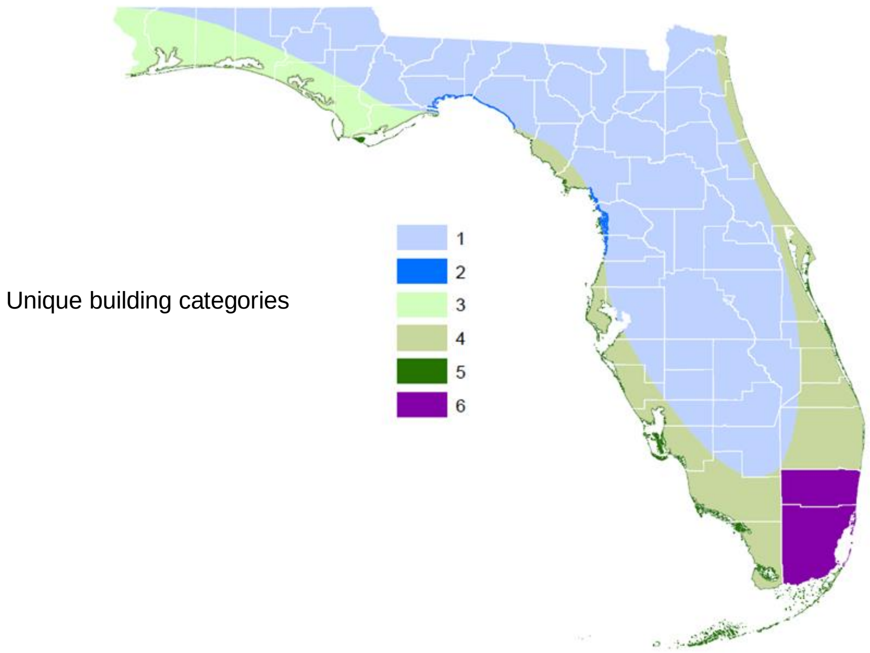


Figure 97. Buildings that Meet the Minimum Requirements of FBC 2001

Table 62 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 62. 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
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, AIR has identified eleven unique building categories for Florida, as listed in Table 63, by taking into consideration the design wind speed, terrain exposure category, and the requirements of WBDR and HVHZ.

Table 63. Building Categories According to FBC 2010

Building Category	Wind Speed*** (mph)	Exposure	WBDR**
1	115 ≤ < 130	B	No
2		C	No
3	130 ≤ < 140	B	No
4		C	No
5		B	Yes
6		C	Yes
7	140 ≤ < 155	B	Yes
8		C	Yes
9	≥ 155	B	Yes
10		C	Yes
11	HVHZ*	C	Yes

* 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 98 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 AIR individual risk module that meet the minimum requirements of the Florida Building Code 2010. For example, AIR 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.

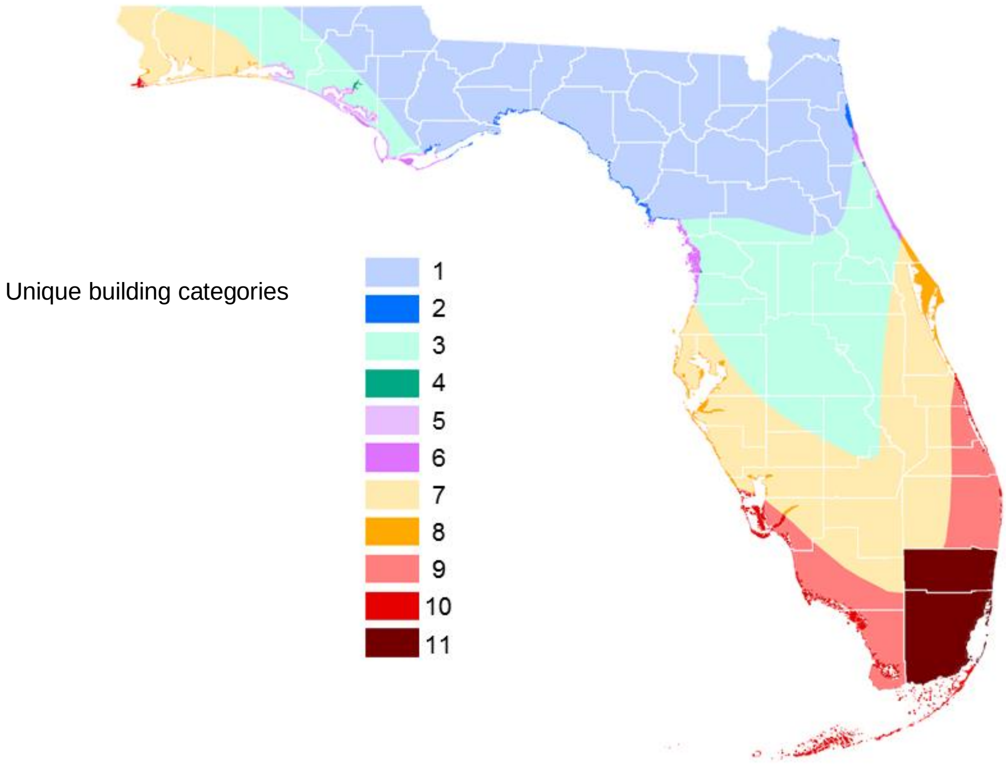


Figure 98. Buildings that Meet the Minimum Requirements of the Florida Building Code 2010

Table 64 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 64. 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

Parameter	Building 11
Exterior Doors	Impact Resistant - Reinforced
Wall Attached Structures	None
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 65 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 65. 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.

AIR 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 AIR 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 AIR secondary characteristics, AIR has developed a list of characteristics that provide a similar range of relativities. The DCA features and closest AIR selections are shown in Table 66.

Table 66. DCA Features and Corresponding AIR Secondary Characteristics

DCA Feature	**Similar AIR Category and Selections**
Opening Protection None Basic Hurricane	Window Protection None Non-Engineered Shutters Engineered Shutters
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 AIR 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 AIR 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.

Appendix 10: Remapped ZIP Codes

FCHLPM ZIP	Remapped ZIP
32004	32082
32006	32003
32007	32177
32026	32091
32030	32068
32035	32034
32041	32097
32042	32044
32050	32068
32056	32055
32072	32087
32079	32043
32085	32084
32099	32220
32105	32180
32111	34472
32115	32114
32116	32118
32120	32114
32123	32119
32133	32179
32135	32137
32138	32666
32143	32136
32147	32148
32157	32181
32158	32159
32160	32656
32170	32168
32173	32174
32178	32177
32182	32134
32183	32179
32185	32666
32192	32617
32201	32202
32203	32204
32723	32724

FCHLPM ZIP	Remapped ZIP
32231	32207
32232	32209
32235	32225
32236	32205
32239	32277
32240	32250
32241	32257
32245	32246
32247	32207
32255	32216
32302	32301
32313	32304
32314	32305
32326	32327
32337	32344
32341	32340
32345	32344
32353	32351
32357	32331
32360	32334
32361	32344
32362	32305
32402	32401
32410	32456
32411	32408
32417	32407
32422	32433
32432	32442
32434	32433
32447	32446
32452	32425
32457	32456
32463	32428
32513	32503
32516	32506
32521	32507
32522	32501
32959	32927

FCHLPM ZIP	Remapped ZIP
32524	32504
32530	32583
32537	32536
32538	32567
32540	32541
32549	32548
32559	32509
32560	32533
32562	32561
32572	32570
32588	32578
32602	32601
32604	32603
32616	32615
32627	32601
32633	32640
32634	32686
32635	32605
32639	34449
32644	32626
32654	32640
32655	32643
32658	32615
32662	32640
32663	32686
32664	32667
32681	32667
32683	32621
32692	32680
32697	32054
32704	32712
32706	32744
32710	32818
32716	32714
32719	32708
32721	32724
32722	32720
33419	33404

FCHLPM ZIP	Remapped ZIP
32727	32726
32728	32725
32733	32792
32739	32738
32747	32771
32756	32757
32762	32765
32768	32712
32772	32771
32774	32763
32775	32754
32777	32757
32781	32780
32790	32789
32791	32779
32793	32792
32794	32751
32802	32801
32853	32803
32854	32804
32855	32805
32856	32806
32857	32807
32859	32809
32867	32817
32872	32822
32878	32828
32886	32801
32910	32907
32912	32904
32919	32901
32932	32931
32936	32935
32941	32940
32954	32953
32957	32958
33646	33647
33655	33602
33660	33619
33672	33602

FCHLPM ZIP	Remapped ZIP
32961	32960
32964	32963
32965	32962
32969	32966
32970	32967
32978	32958
33001	33050
33002	33012
33017	33015
33022	33020
33041	33040
33045	33040
33052	33050
33061	33060
33072	33069
33075	33065
33077	33071
33081	33021
33082	33027
33084	33024
33101	33128
33112	33172
33114	33134
33152	33122
33164	33162
33188	33174
33231	33131
33234	33134
33261	33181
33269	33169
33307	33334
33310	33311
33318	33317
33329	33328
33335	33316
33416	33406
33862	33852
33863	33860
33867	33898
33871	33870

FCHLPM ZIP	Remapped ZIP
33420	33410
33422	33417
33424	33436
33425	33435
33427	33486
33429	33432
33443	33441
33448	33446
33454	33463
33459	33440
33464	33460
33466	33461
33468	33458
33474	33437
33475	33455
33482	33445
33497	33428
33503	33598
33508	33511
33521	34785
33524	33540
33526	33525
33530	33567
33537	33523
33539	33542
33550	33584
33564	33566
33568	33569
33571	33573
33574	33525
33586	33570
33587	33527
33593	33523
33595	33594
33601	33602
33608	33621
34265	34266
34267	34266
34268	34266
34270	34243

FCHLPM ZIP	Remapped ZIP
33675	33605
33680	33610
33684	33614
33685	33615
33687	33617
33733	33713
33740	33706
33741	33706
33743	33710
33758	33765
33766	33759
33769	33765
33775	33772
33779	33770
33780	33781
33784	33713
33802	33815
33804	33805
33806	33803
33807	33813
33820	33830
33826	33825
33831	33830
33835	33834
33836	33837
33840	33803
33845	33844
33846	33812
33847	33830
33848	34758
33851	33844
33856	33898
33858	33837
34742	34741
34745	34744
34749	34748
34755	34715
34770	34769
34778	34787

FCHLPM ZIP	Remapped ZIP
33877	33859
33882	33881
33883	33881
33888	33884
33902	33901
33906	33907
33910	33904
33911	33907
33915	33990
33918	33917
33927	33953
33929	33928
33930	33935
33932	33931
33944	33471
33945	33922
33951	33950
33970	33936
33975	33935
33994	33905
34101	34102
34133	34135
34136	34135
34137	34114
34143	34142
34146	34145
34204	34203
34206	34205
34218	34217
34220	34221
34230	34236
34250	34221
34264	34203
34789	34788
34948	34950
34954	34950
34958	34957
34973	34974
34979	34981

FCHLPM ZIP	Remapped ZIP
34272	34275
34274	34275
34276	34231
34277	34239
34278	34234
34280	34209
34281	34207
34282	34207
34284	34285
34290	34286
34421	34420
34423	34429
34430	34431
34447	34448
34451	34450
34464	34465
34477	34474
34483	34472
34487	34448
34489	34488
34492	34491
34603	34601
34605	34601
34611	34606
34636	34601
34656	34653
34660	34683
34679	34667
34680	34652
34682	34683
34712	34711
34729	34715
34740	34760
34985	34952
34991	34990
34992	34997
34995	34994

Appendix 11: List of Acronyms

Acronym	Meaning
AAL	Average Annual Loss
AIRPort	AIR intranet
ACV	Actual cash value
ALERT	AIR Loss Estimates in Real Time
AOML	Atlantic Oceanographic and Meteorological Laboratory
BCP	Business Continuity Plan
CCSG	AIR’s Consulting and Client Services Group
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
DMG	AIR’s Data Management Group
DMZ	Demilitarized zone
DR	Disaster Recovery
EP	Exceedance probability
ERT	Emergency Response Team
ESDU	Engineering Sciences Data Unit
FBC	Florida Building Code
FCHLPM	Florida Commission on Hurricane Loss Projection Methodology
FHCF	Florida Hurricane Catastrophe Fund
FSA	Forward sortation area
FTP	File transfer protocol
GB	Gigabyte
GIS	Geographic information system
GWRF	Gradient Wind Reduction Factor
HIPAA	Health Insurance Portability and Accountability Act
HPC	High performance computing
HRD	Hurricane Research Division
HTML	HyperText Markup Language
HURDAT2	Revised Atlantic Hurricane Database

Acronym	Meaning
HURSIM	AIR’s research hurricane simulation code
HVHZ	High-Velocity Hurricane Zone
ID	Identification
IRM	Individual Risk Module
ISO	Insurance Services Office
ITV	Insurance to value
Kt	Knot (unit)
LAN	Local area network
LDU	Local delivery unit
LRFD	Load and Resistance Factor Design
LULC	Land Use Land Cover
METAR	A format for reporting weather information
Model 21	AIR Hurricane Model for the U.S.
MRLC	Multi-Resolution Land Characteristics
MSDN	Microsoft Developer Network
NCCI	National Council on Compensation Insurance
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
OS	Operating system
PC	Personal computer
PDF	Portable Document Format
PIAF	Project Information and Assumptions Form
PM	Product Management
PML	Probable maximum loss
PWF	Peak Weighting Factor
QA	Quality assurance
RAF	Radial Adjustment Function
RAM	Random access memory
Rmax	Radius of maximum winds
RMT	Recovery Management Team
SDG	AIR’s Software Development Group
SSH	Secure Shell

Acronym	Meaning
SQL	Structured Query Language
SST	Sea surface temperature
TB	Terabyte
TFS	Team Foundation Server
UI	User interface
USPS	United States Postal Service
VB	Visual Basic
VC	Visual C++
Vmax	Maximum sustained surface wind speed
VPN	Virtual private network
VSS	Visual SourceSafe
WBDR	Wind-borne Debris Region
ZIP	Zone Improvement Plan

About AIR Worldwide

AIR Worldwide (AIR) provides risk modeling solutions that make individuals, businesses, and society more resilient to extreme events. In 1987, AIR Worldwide founded the catastrophe modeling industry and today models the risk from natural catastrophes, supply chain disruptions, terrorism, pandemics, casualty catastrophes, and cyber incidents. Insurance, reinsurance, financial, corporate, and government clients rely on AIR's advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, longevity modeling, site-specific engineering analyses, and agricultural risk management. AIR Worldwide, a Verisk (Nasdaq:VRSK) business, is headquartered in Boston, with additional offices in North America, Europe, and Asia. For more information, please visit www.air-worldwide.com.

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