AIR Worldwide

Prepared for Florida Commission Professional Team

About AIR Worldwide

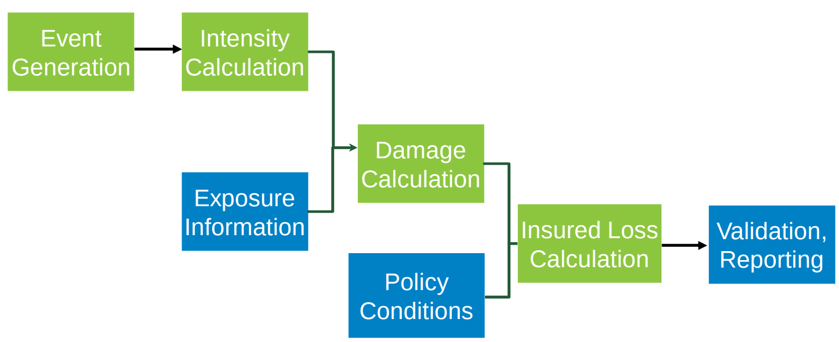
- AIR Worldwide (AIR) is founded on the sciences underlying catastrophe risk
- AIR delivers this science through various software and consulting services
- Clients rely on catastrophe model outputs as key inputs into their overall risk management program
- Part of AIR's mission is to ensure the results of analyses based on our models are represented and interpreted properly by all users

Verisk Insurance Solutions

ISO AIR WORLDWIDE XACTWARE

Overview of the AIR Atlantic Tropical Cyclone Model v14.0.1

AIR Atlantic Tropical Cyclone Model Components



AIR's Previous Update in 2010 Touched All Aspects of the Model

- Hazard update incorporated new data, new science, and new technology on hurricane structure and evolution
- New research and observations of 4-D storm structure integrated into the hurricane model
- New land use data from the USGS used to develop updated local wind adjustments
- Direction of the upstream wind explicitly modeled
- Inland filling rates and reintensification introduced based on new data and recent experience
- Basinwide catalog provides consistent view of risk across U.S., Caribbean, Offshore, and Mexico

AIR's Previous Update in 2010 Touched All Aspects of the Model (cont.)

- Vulnerability update incorporated new claims data and new engineering research
- Incorporation of new data and engineering
  - Significant increase in detailed company claims data
  - Wind vulnerability analyses
  - Data from damage surveys
- Explicit modeling of the evolution of building codes and their enforcements across all hurricane states
- Refinements in vulnerability relationships
  - Significant changes to commercial vulnerability and commercial contents
  - Secondary risk characteristics
  - Industrial facilities

Continued Commitment to External Peer Review for Submission of Model Version 14.0.1

- U.S. Hurricane Model Version 12.0 Set a New Precedent for Comprehensive External Peer Review, but our commitment to external peer review continues with Version 14.0.1

Vulnerability

Dr. Carol Friedman, Louisiana State University

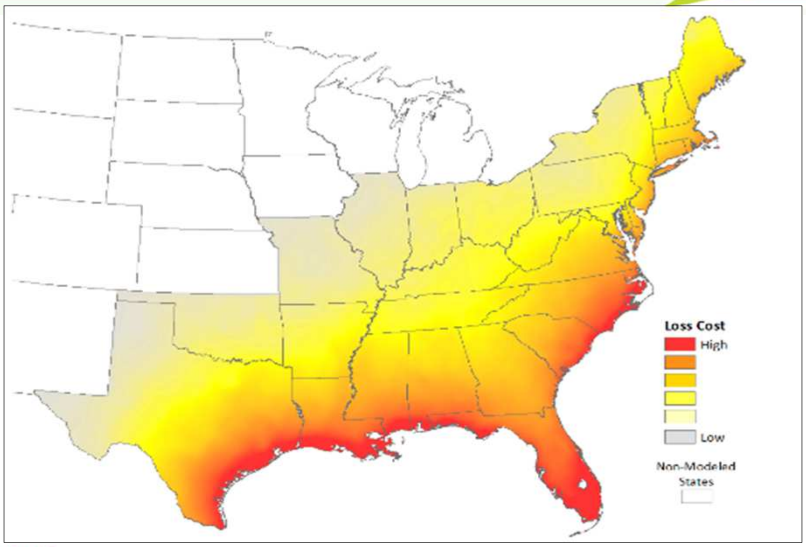
Actuarial

John W. Rollins, FCAS, MAAA, Rollins Analytics

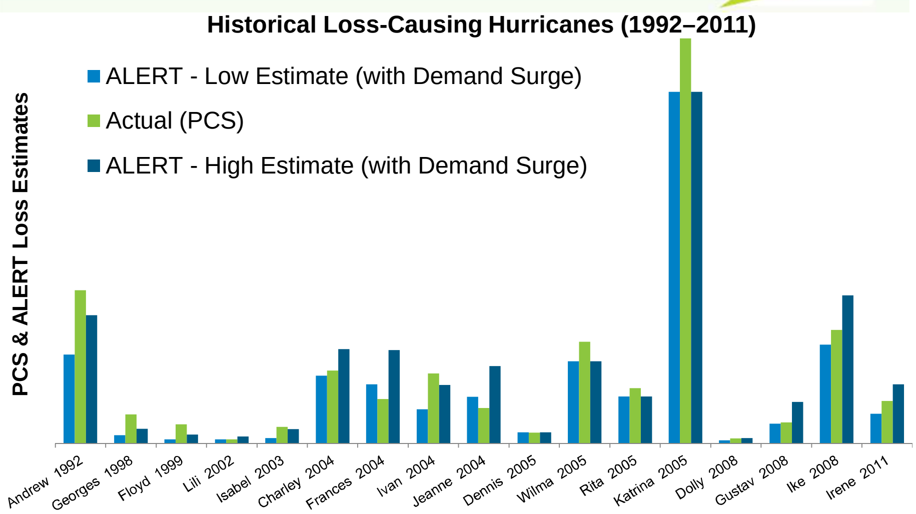
Computer

Ms. Narges Pourghasemi, Senior Software Engineer and Software Consultant

AIR Model Provides Comprehensive View of the Risk

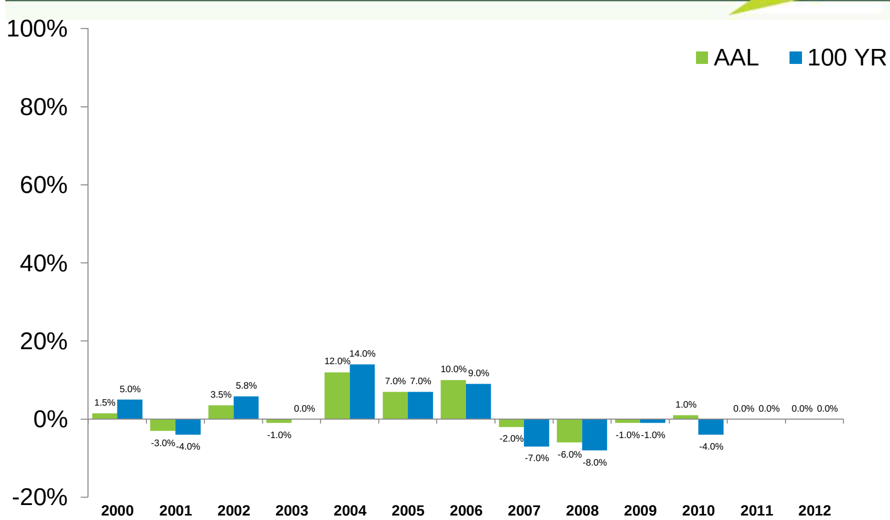


Model Produces Reasonable and Unbiased Loss Estimates in Real Time



ALERT: Low & high estimates for Hurricanes Dennis, Wilma, Rita, and Katrina represent the single, final loss estimate for each storm and not a range of (low-to-high) losses.

AIR U.S. Hurricane Model Industry Loss Changes 2000–2012



Note: The chart excludes the changes in the model submitted to the Commission.

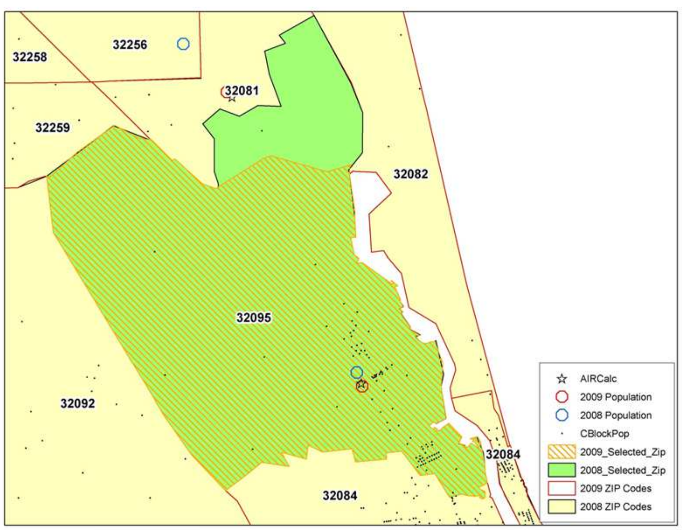
Scope of Model Updates in 2012

- The historical storm set has been updated and a new stochastic catalog was generated
- The ZIP Code database was updated
- Support for new lines of business in the U.S.

Model Component Percent Change

- ZIP Code Database -0.4%
- Event Generation Module -1.9%
- Total Model Change -2.3%

Adoption of Latest USPS ZIP Codes Changes CLASIC/2 ZIP Boundaries and Centroids



HURDAT and Historical Catalog Updates

- AIR's new historical catalog is based on HURDAT as of August 15, 2011 and includes reanalysis through 1930
- Landfall information is drawn from the publication NHC-6 (replacing TPC-5)
- Impact on the Florida region:
  - ➢ No new landfalls during 2009 and 2010
  - ➢ Hurricane 1925_04 downgraded to a tropical storm
  - ➢ Landfall changes for hurricanes 1928_04 and 1929_02
  - ➢ Intensity and track changes for several other storms
- The overall impact on the stochastic catalog is a decreased frequency of Florida landfalls

Update of AIR's Stochastic Catalog

- The updates have been implemented by deleting an appropriate fraction of Florida landfalls from the stochastic catalog
- The proportion of storms deleted varies by coastal location and intensity
- The validation of the final landfall counts involves
  - ➢ Comparison between historical and simulated storm counts by coastal segment
  - ➢ Comparisons between historical and simulated frequencies in Form M-1

Update of AIR's Stochastic Catalog (cont.)

- The removal of storms from the stochastic catalog is limited to Florida landfalls
- A comparison of the historical and modeled frequencies in version V12 of the catalog showed that no adjustments were warranted for AL/MS and Georgia, or for Florida by-passing storms

Update of AIR's Vulnerability Module

- Addition of pleasure boats and yachts line of business
- Addition of builder's risk modeling
- Updated unknown year-built modifiers based on zipcode updates

The AIR Hurricane Model

AIR Atlantic Tropical Cyclone Model V14.0.1
Implemented in CLASIC/2 V14.1.0

PRESENTATION TO THE FLORIDA COMMISSION ON HURRICANE LOSS PROJECTION METHODOLOGY

Model Identification

- Name of model and version: **Atlantic Tropical Cyclone Model V14.0.1**
- Program: **CLASIC/2 V14.1.0**

General Overview of the Atlantic Tropical Cyclone Model Version 14.0.1

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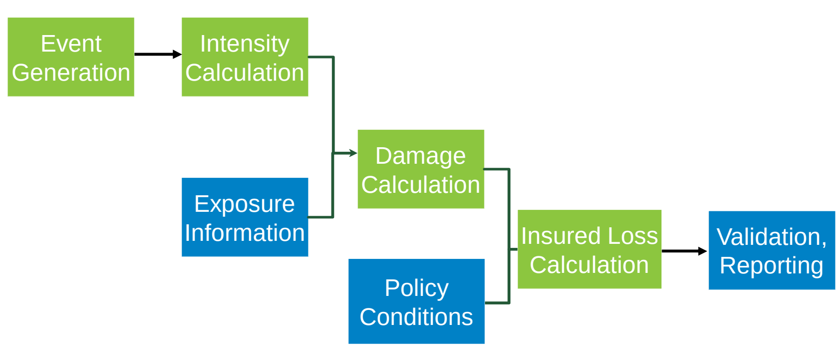
AIR Atlantic Tropical Cyclone Model Components



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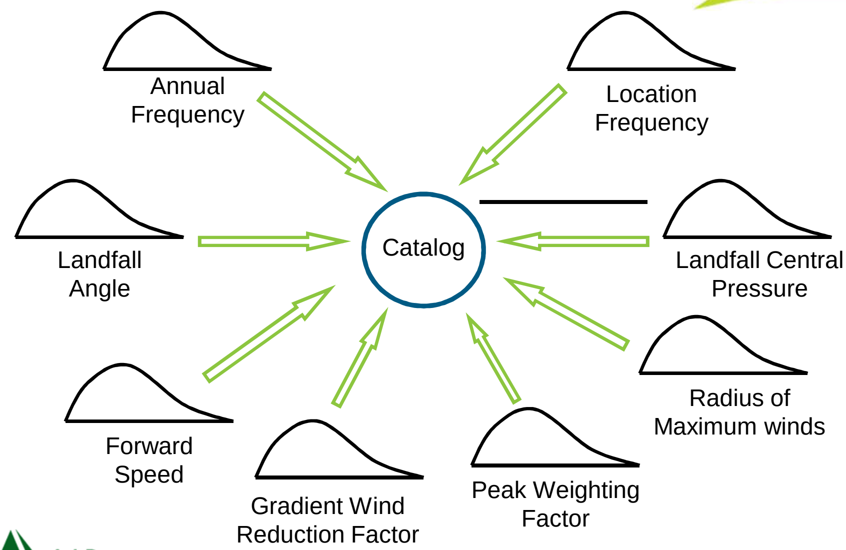
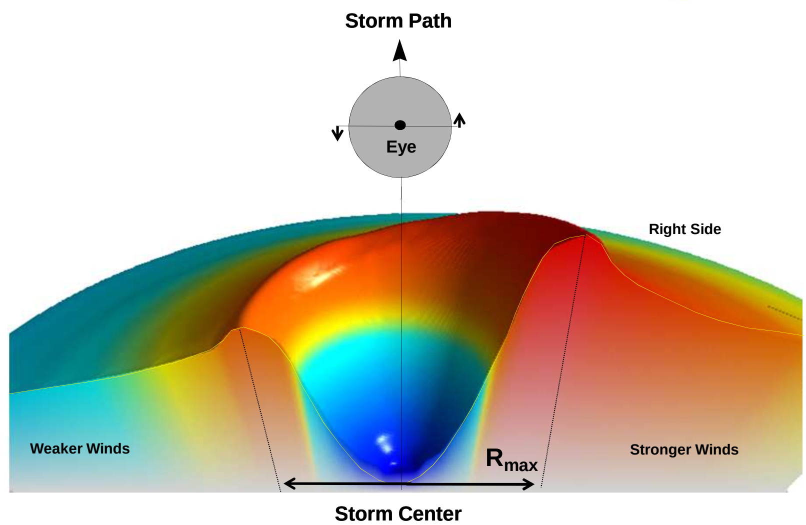
Simulated Variables in Hurricane Event Generation



Probability Distributions for Key Model Parameters

- Annual landfall frequency
  - Negative Binomial distribution
- Landfall location
  - CDF estimated using historical landfall frequencies
- Landfall central pressure
  - Combination of Weibull distributions
- Radius of maximum winds
  - Function of central pressure and latitude
- Forward speed
  - Lognormal distribution
- Landfall angle
  - Mixture of Normal distributions
- Gradient Wind Reduction Factor, Peak Weighting Factor
  - Based on Bivariate Normal distribution

Windfield Cross Section



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Local Wind Speed Calculation

Gradient level 10-minute storm maximum wind	Gradient level 10-minute wind at location	Over water surface (10-meter) 10-minute wind at location	Over water surface (10-meter) 1-minute wind at location	Earth relative over water surface (10-meter) 1-minute wind at location	Earth relative over actual surface 10-meter 1-minute wind at location
Compute ***Gradient Level Maximum Wind*** →	Apply ***Radial Decay*** of Gradient Wind at Location →	Apply ***GWRF at Location*** →	Apply ***Averaging Time (Gust) Factor*** →	Account for ***Asymmetry*** in Surface Wind →	Apply ***Friction Factor***
Function of: Central pressure[1] Peripheral pressure[2] Radius of max winds[1,3] Latitude	Function of: Max gradient wind Radius of max winds[1,3] Latitude Distance from center	Function of: Gradient Wind Reduction Factor[1] Peak Weighting Factor[1] Time Distance from center	Function of: Effective roughness length[2] Wind Direction	Function of: Forward speed[1] Beta (angle between track and wind) [4]	Function of: Effective roughness length[2] Wind Direction

[1] Stochastically drawn by storm
[2] Functional by location
[3] Functional in time
[4] Function of other storm parameters

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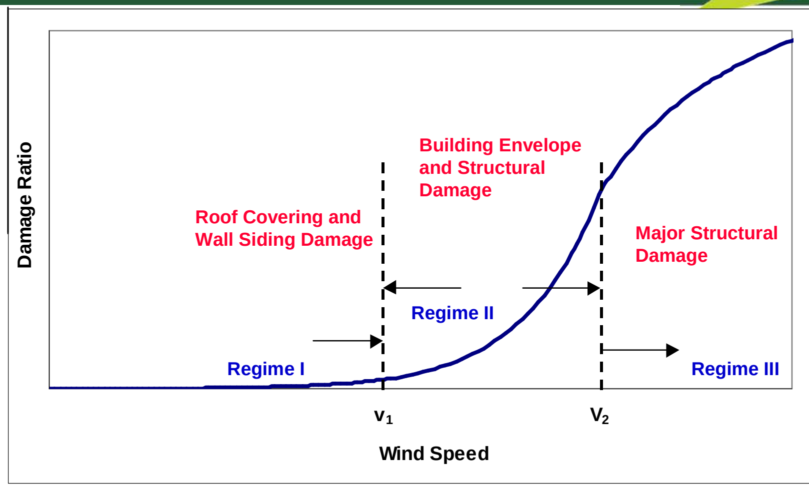
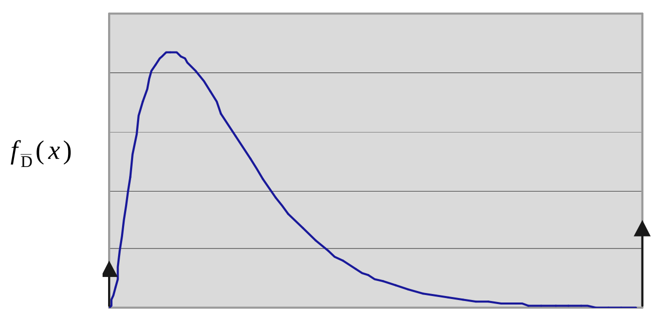
Typical Vulnerability Function

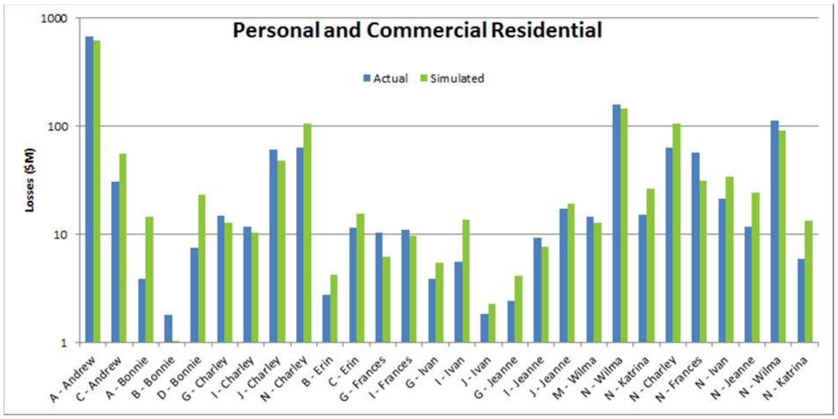


Probability Distribution around the Mean Damage Ratio



$$\text{Expected Insured Loss} = \int_{x=0}^{1} f_{\overline{D}}(x)\,\max\{0, \text{Coins\%} * [\min(x * R_V, P_L) - \text{DED}]\}\,dx$$

Validation of the Atlantic Tropical Cyclone Model Version 14.0.1



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Overview of Changes to Atlantic Tropical Cyclone Model Version 14.0.1 Implemented in CLASIC/2 Version 14.1.0

- The 2012 updates to the AIR Atlantic Tropical Cyclone Model (implemented in CLASIC/2 Version 14.1) are:
  - Event generation module (i.e. Catalog) – to reflect the August 2011 version of HURDAT
  - ZIP Code database – ZIP Code and Industry Exposure databases are updated each year
  - Support for builder's risk and pleasure boat risks

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AIR Scientists and Engineers Have Contributed Published Research to the Scientific Community

Hazard

- Xu, Na, James E. Saiers, Henry F. Wilson, and Peter A. Raymond 2012, "Simulating Streamflow and Dissolved Organic Matter Export from a Forested Watershed," *Water Resources Research*, 48, W05519, 2012.
- Kwon, D. K., A. Kareem, K. Butler 2012, "Gust-Front Loading Effects on Wind Turbine Tower Systems," *Journal of Wind Engineering and Industrial Aerodynamics*, 104-106, 109-115. May 01, 2012.
- Kennedy, A. B., U. Gravois, B. C. Zachry, J. J. Westerink, M. E. Hope, J. C. Dietrich, M. D. Powell, A. T. Cox, R. L. Luettich, and R. G. Dean 2011, "Origin of the Hurricane Ike Forerunner Surge," *Geophysical Research Letters*, 38, L08608. April 21, 2011.
- Hoffman, Ross N., Peter Dailey, Susanna Hopsch, Rui M. Ponte, Katherine Quinn, Emma M. Hill, Brian Zachry, 2010: An Estimate of Increases in Storm Surge Risk to Property from Sea Level Rise in the First Half of the Twenty-First Century. *Wea. Climate Soc*., Vol. 2, 271–293. October 01, 2010.
- Kennedy, A. B., U. Gravois, and B. Zachry 2011, "Observations of Landfalling Wave Spectra During Hurricane Ike," *Journal of Waterway, Port, Coastal, and Ocean Engineering*, 137(3), 142–145. November 11, 2010.

AIR

AIR Scientists and Engineers Have Contributed Published Research to the Scientific Community

Vulnerability

- Yu, D., K. Butler, A. Kareem, J. Glimm, and J. Sun 2013, "Simulation of the Influence of Aspect Ratio on the Aerodynamics of Rectangular Prisms," *Journal of Engineering Mechanics*139(4), 429–438. June 07, 2012
- Butler, K. and A. Kareem "Anatomy of Glass Damage in Urban Areas during Hurricanes," Proceedings of the ATC-SEI Advances in Hurricane Engineering, October 2012.
- Kennedy, A. B., S. Rogers, A. Sallenger, U. Gravois, B. Zachry, M. Dosa, and F. Zarama 2011, "Building Destruction from Waves and Surge on the Bolivar Peninsula during Hurricane Ike," *Journal of Waterway, Port, Coastal, and Ocean Engineering*, 137(3), 132–141. November 11, 2010.
- Jain, V.K., Guin, J. Modeling Business Interruption Losses From Wind Storms For Insurance Portfolios. 11th Americas Conference on Wind Engineering. San Juan, Puerto Rico. June, 2009
- Jain, V.K., Guin, J., and He, H., Statistical Analysis of 2004 and 2005 Hurricane Claims Data. 11th Americas Conference on Wind Engineering. San Juan, Puerto Rico. June 22-26, 2009.

AIR

External Peer Review of Atlantic Tropical Cyclone Model Version 14.0.1

Vulnerability

Dr. Carol Friedland, Louisiana State University

Actuarial

John Rollins, FCAS, MAAA, Rollins Analytics

Computer Science

Narges Pourghasemi, Independent Auditor

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Summary of Model Changes

2012 Updates to AIR's Atlantic Tropical Cyclone Model

	Percent Change
Event Generation Module	-1.9%
Zip Code Database Update	-0.4%
Overall Change	**-2.3%**

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Event Generation Module

- For the 2012 model release, AIR's historical storm set has been updated, incorporating track information from the August 2011 version of HURDAT. The probability distributions used for annual landfall frequency and landfall location in the stochastic catalog have been updated accordingly and a new stochastic catalog has been generated.
- These updates have resulted in a 1.9% decrease in losses.

ZIP Code Database Update

- The ZIP Code database is updated each year. For each new ZIP Code centroid, the following data needs to be re-estimated: distance from coastline, elevation and surface roughness. This is a technical update. This individual update has resulted in minor changes to population-weighted centroids. The Industry Exposure Database is also updated every year, affecting estimated industry losses and resulting demand surge factors. The impact on losses is a 0.4% decrease.

Explanation of Resubmitted Pages

AIR

Explanation of Resubmitted Pages

- AIR resubmitted pages in response to the Deficiencies Letter.
  - Deficiencies addressed and verified by the Professional Team are
    - Model Submission Checklist – Provided explanation for Item 6d
    - Standard G-1, Disclosure 5.C – Revised scale for maps
    - Standard G-2, Disclosure 3.B – Positive statement that there were no unresolved or outstanding issues from Dr. Friedland's 2012 peer review
    - Standard M-4, Disclosure 10 – Response revised to include Hurricane Jeanne

AIR

Explanation of Resubmitted Pages (Cont.)

- AIR resubmitted pages in response to the draft Professional Team Report.
  - Editorial changes addressed and verified by the Professional Team
    - Standard M-4, Disclosure 9 – Corrected references to Figures 10 and 11
    - Standard V-1, Figure 14 – changed the word "of" from upper to lower case
    - Standard V-1, Disclosure 3 – removed extra comma from last sentence
- AIR resubmitted pages in response to the draft Professional Team Report
  - Corrections addressed and verified by the Professional Team
    - Standard G-1, Disclosure 4 – Corrected reference to Actuarial source, *An Introduction to the Bootstrap*
    - Standard G-2, Disclosure 1.E.2.A – Added Prashant A. to the table of Computer Science modeler personnel
    - Standard G-2, Disclosure 1.E.2.B – Removed Prashant A. from the list of new employees; added Praveen P. to the list of new employees
    - Standard G-2, Disclosure 1.E.3 – Corrected dates referenced in conjunction with the last meteorology peer review and the 2009 vulnerability peer review; corrected page number reference to Ms. Pourghasemi's CV
    - Standard V-1, Disclosure 1, Figure 14 – Made edits to the flow chart
    - Standard V-2.C – changed reference to "losses" in the note under Figure 29 to "data"

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Explanation of Resubmitted Pages (Cont.)

- AIR resubmitted pages in response to the draft Professional Team Report.
  - Additions
    - Standard G-1, Disclosure 4 – Added three Meteorological References
    - Standard V-1, Disclosure 11 – Added statements about apartment and condo type structures
    - Standard V-2.A – Added a disclosure under Figure 27 about client data used in the plot

AIR

2011 General Standards

AIR

G-1 Scope of the Computer Model and Its Implementation

- The AIR hurricane model projects loss costs for personal lines residential property from hurricane events.
- In its model update and implementation, AIR maintains a documented process to assure continual agreement and correct correspondence of databases, data files, and computer source code to slides, technical papers and/or modeling organization documents.
- There has been no change to the scope of the computer model or its implementation.

AIR

G-2 Qualifications of Modeling Organization Personnel and Consultants

- AIR employs a large, full-time professional staff in actuarial science, computer science, insurance and reinsurance, mathematics, statistics, meteorology, and other physical sciences, software engineering, and structural engineering.
- Resumes of new employees were provided to the professional team.

G-3 Risk Location

- ZIP Codes used in the model are updated annually with information provided by the United States Postal Service (USPS).
- The AIR model uses population-weighted ZIP Code centroids.
- AIR maintains documentation providing step-by-step instructions for processing the centroid related files supplied by AIR's vendor.
- AIR performs quality control measures to verify the positional accuracy of the vendor-supplied population centroids and ensure their appropriateness.
  - Overlay of the population-weighted centroids with the ZIP Code boundaries
  - Display of the 2011 census block locations and their corresponding population values
  - Independent generation of population weighted centroids for each ZIP Code

G-4 Independence of Model Components

- All components of the AIR model are theoretically sound and independently derived.
- Each component is independently validated.

AIR

G-5 Editorial Compliance

- The submission was reviewed in its entirety for grammatical correctness, typographical accuracy and completeness by an experienced technical editor and writer.
- The primary reviewer read and understood the submission requirements as listed in the Report of Activities prior to working on AIR’s submission, and verified the submission was editorially correct.

AIR

2011 Meteorological Standards

AIR

M-1 Base Hurricane Storm Set

- The Base Hurricane Storm Set consists of, at the time the model was developed, the latest version of HURDAT supplemented with landfall data from the NOAA Technical Memorandum NWS TPC-5. This version of HURDAT is valid as of August 15, 2011 and spans the years 1900-2010.
- 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.

AIR

M-2 Hurricane Parameters and Characteristics

- Methods for depicting all modeled hurricane characteristics are based on information documented in the scientific literature or on research conducted by AIR and accepted by the Commission.

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M-3 Hurricane Probabilities

- AIR-modeled probability distributions for hurricane strength, eye diameter, forward speed, radii for maximum winds, and radii for hurricane force winds are consistent with observed historical hurricanes in the Atlantic basin and are bounded by observed global extremes as documented in accepted scientific literature available to the Commission.
- AIR-modeled hurricane probabilities for category 1 - 5 hurricanes reasonably match the historical record and are consistent with those observed for each geographical area of Florida, Alabama, Georgia and Mississippi.
- 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.

AIR

M-4 Hurricane Windfield Structure

- The modeled windfield is consistent with the distribution of observed winds for historical storms affecting Florida.
- The AIR model uses USGS land use / land cover (LULC) classifications by category and assigns appropriate roughness lengths based upon available scientific literature.
- 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. The effect of the vertical variation of winds is accounted for in the development of the vulnerability functions for structures with varying heights.

M-5 Landfall and Over-Land Weakening Methodologies

- 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 recent peer reviewed journals.
- The transition of winds from over-water to over-land within the model is based on established meteorological and engineering relationships for boundary layer winds. The methodology has been refined using the latest high-fidelity state-of-the-science wind data from recent research field projects.

M-6 Logical Relationships of Hurricane Characteristics

- The magnitude of asymmetry increases as the translation speed increases, all other factors held constant.
- The mean windspeed decreases with increasing surface roughness (friction), all other factors held constant.

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2011 Vulnerability Standards

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V-1 Derivation of Vulnerability Functions

- AIR hurricane model vulnerability functions are based on structural engineering research publications, field damage surveys conducted by wind engineering experts, and analyses of detailed loss data from clients.
- The AIR vulnerability functions and associated uncertainties have been peer reviewed internally and by external experts and are theoretically sound and consistent with published engineering research.
- Residential building stock classification in the model are representative of Florida construction for personal and commercial residential properties
- The AIR hurricane model uses vulnerability functions for approximately 32 different residential construction types, and includes an individual risk analysis module that accounts for a wide range of construction characteristics. For commercial residential construction types, vulnerability varies by height. For single family homes, vulnerability functions do not vary by height.
- AIR engineers have developed separate vulnerability functions for the primary structure, including mobile homes, the appurtenant structures, contents and time element coverages.

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V-1 Derivation of Vulnerability Functions (Cont.)

- The model starts calculating losses at 40 mph one-minute average wind speed. This wind speed is found reasonable based on the findings from engineering research, damage surveys and actual claims data from historical events.
- Vulnerability functions include damage due to wind speed and pressure, water infiltration, and missile impact associated with hurricanes. Wind vulnerability functions in the model does not include the explicit damage to the structure of flood, storm surge, and wave actions.

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V-2 Derivation of Contents and Time Element Vulnerability Functions

- The relationship among the modeled structure and contents loss costs is reasonable based on comparisons to client data.
- Time element vulnerability function derivations consider the estimated time required to repair or replace the property.
- The relationship between the modeled structure and time element vulnerability functions and historical structure and time element losses is reasonable.
- Time element vulnerability functions used by the model include time element coverage claims associated with wind, flood, and storm surge damage to the infrastructure caused by a hurricane to the extent that such losses are in the validation data used.

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V-3 Mitigation Measures

- Methods for estimating the effects of mitigation measures, as described in Appendix 9, *U.S. Hurricane Individual Risk Methodology*, are theoretically sound, both individually and in combination.
- AIR's mitigation model has been developed using a structured, knowledge-based expert system that applies structural engineering expertise and building damage observations made in the aftermath of actual hurricanes.

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2011 Actuarial Standards

A-1 Modeling Input Data

- Any adjustments, edits, inclusions or deletions made to client company input data are based upon accepted actuarial, underwriting and statistical procedures.
- Assumptions that relate to a client's input data are identified on the analysis options form, which is reported along with output of the model. Assumptions related to any missing values are documented and approved by the client as being actuarially sound.

A-2 Event Definition

- Modeled loss costs and 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.
- Additional Living Expense (ALE or Time Element) loss costs reflect losses due to infrastructure damage caused by a hurricane.

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A-3 Modeled Loss Cost and Probable Maximum Loss Considerations

- AIR's hurricane model produces pure loss estimates. Model loss costs do not include risk load, investment income, premium reserves, taxes, assessment or profit margin.
- The model does not make a prospective provision for economic inflation. Clients' in-force exposures, projected exposures, or hypothetical exposures are input to the model.
- For the purposes of this submission, all modeled loss costs and probable maximum loss levels exclude any provision for direct hurricane storm surge losses.
- Loss cost projections and probable maximum loss levels are capable of being calculated from exposures at a geocoded (latitude-longitude) level of resolution.
- Modeled loss costs and probable maximum loss levels reflect demand surge.
- The methods, data and assumptions used in the estimation of demand surge are actuarially sound.

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A-4 Policy Conditions

- The effects of deductibles, coinsurance and other policy conditions are based on actuarial principles and are properly calculated.
- The relationship among the modeled deductible loss costs is reasonable. Loss costs do decrease as deductibles increase, other factors held constant.
- The AIR model explicitly enables the application of seasonal deductibles in accordance with s. 627.701(5)(a), F.S.

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A-5 Coverages

- Methods used in the development of contents loss costs are actuarially sound. The AIR hurricane model represents damages to contents separately from buildings and appurtenant structures since some policies cover contents only and others provide no contents coverage.
- The methods used in the development of time element coverage loss costs are actuarially sound. Themodel represents losses to time element coverage separately from building, contents and appurtenant structures.

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A-6 Loss Output

- The AIR model uses actuarially sound methods, data and assumptions in the estimation of probable maximum loss levels.
- The AIR model produces loss costs that are logical in relation to risk and do not exhibit a significant change when the underlying risk does not change significantly.
- The loss costs are positive and non-zero for all ZIP Codes.
- Loss costs do not increase as quality of construction, material, workmanship or the presence of mitigation devices or techniques increases, all else being equal, and are consistent with actual insurance data.
- Loss costs do not increase as the quality of building codes and enforcement increases, all else being equal.
- Loss costs do not increase as the presence of fixtures or construction techniques designed for hazard mitigation increases, all other factors held constant.
- Loss costs do decrease as deductibles increase.

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A-6 Loss Output (Cont.)

- The relationship of losses for building, appurtenant structures, contents, and additional living expense to the total loss as produced by the model is reasonable and consistent with actual insurance data.
- Loss cost relationships among coverages, territories, and regions are consistent and reasonable.
- Output ranges are logical based on the type of risk being modeled and deviations are supported.
- Output ranges reflect declining loss costs with increasing deductibles, reflect lower loss costs for masonry construction versus frame, and reflect lower loss costs for residential risk versus mobile home.
- Output ranges generally reflect lower loss costs for inland counties versus coastal counties, and lower loss costs for northern counties versus southern counties.
- Assumptions involving loss cost and probable maximum loss level estimates derived from or validated with historical insured hurricane losses, are appropriate based on the type of risk being modeled.

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2011 Statistical Standards

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S-1 Modeled Results and Goodness-of-Fit

- Historical data available in HURDAT have been used to develop the probability distributions for key model variables such as annual hurricane frequency, landfall location, and central pressure.
- 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 adequacy of the fit has been examined using established procedures such as the Kolmogorov-Smirnov and the Shapiro-Wilk tests. Graphical comparisons using Q-Q plots and other procedures were also performed to confirm the agreement between the historical data and the fitted probability distributions.
- Modeled and historical results reflect statistical agreement using currently accepted scientific and statistical methods appropriate for the various model components.

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S-2 Sensitivity Analysis for Model Output

- AIR scientists and engineers have done extensive sensitivity testing on all aspects of the hurricane model and taken appropriate action.
- This has involved testing alternative probability distributions for key input variables, as well as changing the parameter values of these probability distributions.
- One-parameter-at-a-time as well as multi-parameter studies have been conducted.
- Sensitivity of individual model variables on the estimated losses by state, county, and ZIP Code have been tested.
- Sensitivity of temporal and spatial wind speeds generated by the model has also been investigated.

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S-3 Uncertainty Analysis for Model Output

- AIR scientists and engineers have performed uncertainty analyses involving model input variables such as central pressure, Rmax, and forward speed.
- The studies have focused on the temporal and spatial variability in wind speed as well as loss costs attributable to variation in the input variables.
- One-parameter-at-a-time as well as multi-parameter studies have been conducted.
- Central pressure and the gradient wind reduction factor, in particular, have been found to be important contributors to the uncertainty in the estimated wind speeds as well as the state, county, and ZIP Code level losses.

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S-4 County Level Aggregation

- Convergence graphs and inspection of the loss costs for increasing sample sizes indicate the sampling error is negligible for the 50,000-year simulation used to generate the loss costs.
- AIR uses a constrained Monte Carlo simulation to obtain the average annual loss costs and output ranges. The procedure imposes constraints on the landfall frequency by SS category for each 100-mile coastal segment. The constraints are derived by running the model for 1 million years and scaling the simulated frequencies down to a 50,000-year simulation.

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S-5 Replication of Known Hurricane Losses

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

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S-6 Comparison of Projected Hurricane Loss Costs

- The average annual historical statewide personal and commercial residential loss cost produced using the 2007 FHCF exposure data and the historical storm set covering the period 1900-2010 is $3.445 billion. The average annual statewide personal and commercial residential loss cost produced by the model using a 50,000-year simulation is $4.345 billion. The difference between these two numbers is statistically reasonable.

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2011 Computer Standards

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C-1 Documentation

- The internal and client documentation is presented using formal documentation templates. These templates make apparent the application name, version number, as well as revision history detail, which enables the user to clearly identify the documentation updates as pertinent to the current version.
- A primary document binder containing fully documented sections for each computer standard was made available to the Professional Team.
- All computer software, data files, and databases are fully documented and such documentation was made available to the Professional team.
- At table specifying all changes from the previously accepted model was provided (Previous model is the AIR Atlantic Tropical Cyclone Model v12.0.1 implemented in CLASIC/2 v12.0.4).
- Documentation is separate from the source code and is provided via in-line detailed comments and external higher level documentation that was made available to the Professional Team.

C-2 Requirements

- The CLASIC/2™ requirements specification documents describe functional, user interface, data format, security, performance and other requirements of CLASIC/2™ for the hurricane peril; it also describes design constraints.

- Also available to the Professional Team was a document that itemizes changes to the hurricane model and the corresponding support documentation.

C-3 Model Architecture and Component Design

- A component design document, included in the primary document binder, contains detailed control and data flow diagrams and interface specifications that illustrate the component design of the CLASIC/2™ software system and the architecture of the AIR hurricane model, its components and sub-components.
- Each data file and database that is used by the model has its schema documented in an external document that is part of the document binder.
- The component design document was enhanced to illustrate demand surge. The database documentation was enhanced to reflect new tables resulting from the updated ZIP Codes.

AIR

C-4 Implementation

- AIR maintains a complete set of software engineering practices for coding and documentation guidelines that are followed by the software developers.
- AIR maintains a procedure for procuring and creating data files and databases. AIR has developed documentation that provides component identification from documentation diagrams down to the code level.
- AIR has a table of components in the primary document binder that contains each of the Component names, the Number of lines of code, Comments, and Blank lines.
- AIR has developed documentation that is clearly written and that can by used by new software engineers to gain an understanding of the software being reviewed.
- When new or modified equations/formulas are introduced, the documentation defines all equations, formulas, terms and variable names.

AIR

C-5 Verification

- 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.
- Unit tests are performed for individual software components, independent of all other components, and are documented. In addition, formal testing procedures are conducted, through all successive phases of development from design, coding, initial testing, and regression testing.
- AIR utilizes a Verification Utility program 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.
- AIR verifies the correctness of the databases by validating the source counts and ensuring that the changes are affected on the same number of records. Examples of the verification, including counts on the ZIP changed records, county change records, and ZIP centroid updates.

AIR

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C-6 Model Maintenance and Revision

- Since 1987, AIR has implemented a clearly documented policy for model revision with respect to methodology and data.
- Any enhancement to the model that results in a change in hurricane loss costs also results in a new model version number.
- AIR's software development group employs source revision and control software for all software product development, including CLASIC/2™.
- Available to the Professional Team was a document that identifies the changes between release versions of CLASIC/2™ and the hurricane model.

AIR

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C-7 Security

- AIR has implemented security procedures for access to code, data, and documentation that are in accordance with standard industry practices.
- 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 policy document describes these measures in greater detail.

AIR