The Florida Public Hurricane Loss Model

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- Florida ranks #1 in total insured property value exposed to hurricane wind and #1 in coastal property exposed to storm surge.
- Florida has $3.6 trillion in insured properties of which about $2 trillion are residential, and all are exposed to hurricane risk.
- About 79% is coastal property which is particularly vulnerable to hurricane risk.
- Of this $400 billion in properties may be particularly vulnerable to storm surge.
- Hurricane Katrina and Sandy showed that even Cat 1 and 2 hurricane can cause tremendous storm surge losses.

- In 2001 The Florida Office of Insurance Regulation funded Florida International University to develop a public hurricane loss model for purposes of assessing hurricane wind risk and predicting insured losses for residential properties (both personal and commercial residential).
- Model development was not influenced by OIR.
- The first completed version of the residential model was activated in March 2006. Latest version was activated this September.
- Model has been used over 550 times by the state.
- It has also been used extensively by firms in the insurance industry.

- The wind model went through an extremely rigorous review process
- Model was first certified in 2007 by the Florida Commission on Hurricane Loss Projection Methodology----the gold standard for such models.
- The latest version 5.0 was certified this August.
- Model had to meet 33 major standards in meteorology, engineering, actuarial science, statistics, and computer science
- Deemed to be “accurate and reliable” for predicting insured residential losses in Florida

- Last year the state funded FIU to enhance the FPHLM by adding both a storm surge and inland flooding component.
- The proposed new model will assess storm surge and hurricane related rain flood risk and estimate both the insured and uninsured losses they may create.
- The SSFC enhancement project will take three years and cost at least $4.5 million.

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What is the wind model?

- The model is a very complex, state of the art, set of computer programs.
- The programs simulate and predict how, where and when hurricanes form, their wind speed and intensity and size etc, their track, how they are affected by the terrain along the track after landfall, how the winds interact with different types of structures, how much they can damage house roofs, windows, doors, interior, contents etc, how much it will cost to rebuild the damaged parts, and how much of the loss will be paid by insurers
- Its development required experts in meteorology, wind and structural engineering, statistics, actuarial sciences, finance, GIS, and computer science.

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What can the wind model do?

- The model can generate for a given policy or portfolio of residential policies, the annual average losses and the probable maximum losses. Such loss estimates are typically used by insurance companies as input in the rate making process and are used by state regulators to help evaluate rate filings
- We can do scenario analysis. Once we have ascertained a land falling hurricane's, track, size and wind speed, we can predict the losses they are likely to inflict down to the street level.
- The model has capability to estimate the loss reduction from certain mitigation efforts.

What will the storm surge enhancement do?

- Provide estimates of potential damage to residential properties, both insured and uninsured, from storm surge and inland flood, and how much it may cost to rebuild them
- provide a state of the art innovative non-proprietary integrated wind field/storm surge/flood model that can distinguish wind losses from flood losses and scientifically help resolve the seemingly intractable issue of who should pay for damages
- provide a more refined and actuarially sound method of estimating insured losses and determining fair pricing of all sources of hurricane risk

- provide, for storm surges, estimates of potential cost to the state of rebuilding uninsured properties and communities
- conduct simulations and scenario analysis integrated into GIS overlays that can help state and local government (e.g., DEM) as well as the insurance industry with pre and post hurricane disaster planning and resource allocation and land use planning.
- assess the cost-benefit of disaster mitigation strategies
- provide possible assistance to the regulators, and the insurance and re-insurance industry in the rate making process

Participating Institutions

- Florida International University/ IHRC (lead institution)
- Florida State University
- Florida Institute of Technology
- Hurricane Research Division, NOAA
- University of Florida
- University of Miami
- Notre Dame University
- About 2 dozen professors and experts and over 2 dozen graduate and undergraduate students have been involved in the development and operation of the model.
- Some are leading experts in their field
- All the model operation work and model run is done at FIU
- About half the development and updating work is done at other institutions

The current and past team members are:

Actuarial/Finance Team

• Dr. Shahid Hamid	Dept of Finance and IHRC, FIU PI and Project Director
• Gail Flannery	Actuary, FCAS, AMI Risk Consultant
• Bob Ingco	Actuary, FCAS, AMI Risk Consultant

Meteorology Team

• Dr. Mark Powell	Hurricane Research Division, NOAA
• Dr. Steven Cocke	Dept of Meteorology, FSU
• Bachir Annane	Univ of Miami – CIMAS
• Dr. T.N.Krishnamurti	Dept of Meteorology, FSU
• Dr. George Soukup	Applied physicist, AOML/NOAA
• Neal Dorst	Hurricane Research Division, NOAA

- <u>Storm Surge and Flood Hazard Team</u>

• Dr. Keqi Zhang	Dept. of Earth and Environment and IHRC at FIU, Co-PI.
• Dr. Yuepeng Li	IHRC at FIU
• Dr. Omar Aziz	Dept. of Civil Engineering, FIU
• Dr. Yongzhi Liu	Dept. of Civil Engineering, FIU

Computer Science Team (current members)

• Dr. Shu-Ching Chen*	School of Computer Science, FIU. Co-PI.
• Dr. Mei-Ling Shyu	Dept. of Electrical and Computer Engineering, University of Miami
• Fausto Fleites	CIS Ph.D. candidate at FIU
• Hsin-Yu Ha	CIS Ph.D. candidate at FIU
• Yimin Yang	CIS Ph.D. candidate at FIU
• Dianting Liu	Ph.D. student, University of Miami
• Raul Garcia	CIS student
• Diana Machado	CIS student
• Plus other students	

Engineering Team

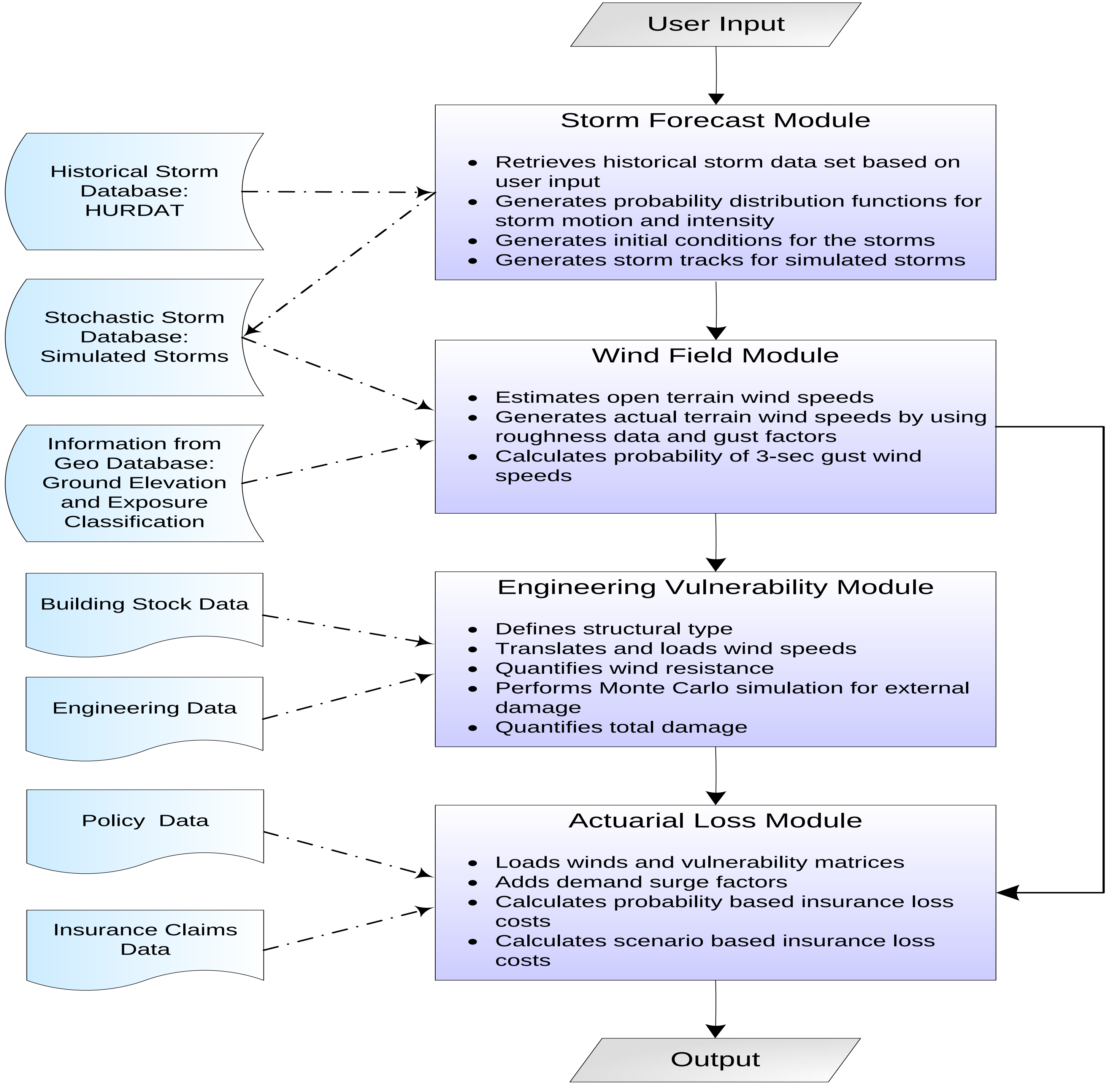
• Dr. Jean Paul Pinelli*	Dept of Civil Engineering, FIT
• Dr. Kurtis Gurley	Dept of Civil Eng, UF
• Dr. Mani Subramaniam	Dept of Mech Engineering, FIT
• Dr. Emil Simiu	Civil Eng, IHRC at FIU and NIST
• Dr. Andrew Kennedy	University of Notre Dame
• Plus students	

Statistics Team

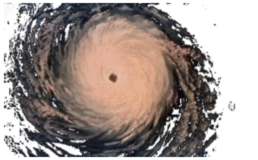
• Dr. Sneh Gulati*	Dept. of Statistics, FIU
• Dr. G. Kibria	Dept. of Statistics, FIU

Model Design

- The model consists of three major components: wind hazard (meteorology), vulnerability (engineering), and insured loss cost (actuarial).
- The major components were developed independently before being integrated.
- The computer platform is designed to accommodate future hookups of additional sub-components or enhancements.


User Input
Storm Forecast Module
Retrieves historical storm data set based on user input
Generates probability distribution functions for storm motion and intensity
Generates initial conditions for the storms
Generates storm tracks for simulated storms
Historical Storm Database: HURDAT
Stochastic Storm Database: Simulated Storms
Wind Field Module
Estimates open terrain wind speeds
Generates actual terrain wind speeds by using roughness data and gust factors
Calculates probability of 3-sec gust wind speeds
Information from Geo Database: Ground Elevation and Exposure Classification
Building Stock Data
Engineering Data
Engineering Vulnerability Module
Defines structural type
Translates and loads wind speeds
Quantifies wind resistance
Performs Monte Carlo simulation for external damage
Quantifies total damage
Policy Data
Insurance Claims Data
Actuarial Loss Module
Loads winds and vulnerability matrices
Adds demand surge factors
Calculates probability based insurance loss costs
Calculates scenario based insurance loss costs
Output

Components of the Wind Model



- **Hurricane threat area definition:** Define the hurricane model domain.
- **Storm genesis model:** Produces the initial conditions derived from historical data that are perturbed to generate thousands of years of stochastic tracks.
- **Storm Track and Intensity Model:** Generates the storm tracks and intensity up to close of land for simulated hurricanes.
- **Inland Storm Decay Model:** Estimates decay after landfall.
- **Wind Field Model:** Generates 1 minute sustained open terrain wind speeds for each of the hurricane affected zip code or grid.

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- **Terrain Roughness Model:** Corrects open terrain wind speed for terrain roughness.
- **Gust Factor Model:** Generates 3 second peak gust wind speeds for each zip code.
- **Wind Probabilities Model**: Generates wind probability distribution for each zip code.
- **ArcIMS environment** to visualize Florida GIS information and the associated data results over the Internet.

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Components of the Vulnerability Model

- Extensive survey was conducted of the building stock in Florida
- **Engineering simulation models**: Simulates for each type of construction, all possible wind damages to the structure, interior, contents, appurtenant structure, as well as ALE.
- **Engineering damage model**: Generates damage matrices for each construction type (frame, masonry, manufactured homes, hip or gable roofs etc.). Produces damage ratios for structure, contents, appurtenant structure, and additional living expense. We have developed over 10,000 vulnerability functions.

- The building codes are proxy by year built. Based on the code regime, weak, medium, and strong vulnerability functions are developed for each region.
- **Engineering Mitigation Model**: Generates vulnerability functions (damages matrices) for mitigated structures (e.g., with shutters, impact glass windows, braced gable ends, hip roof, wall to roof straps and ties, rated shingle roofs etc.).

Components of the Actuarial Model

- **Demand Surge Model:** Estimates both demand surge for a range of hurricane losses, and the probabilistic demand surge factor.
- **Probabilistic Loss Cost Actuarial Model:** Generates expected annual loss costs for each policy, or portfolio of policies, or by zip code, county, construction type, policy type etc. Adjusts for deductibles and limits etc.. Generates combined expected losses as well as structure, content, AP and ALE loss. Also generates probable maximum loss.
- **Scenario based Loss Cost Actuarial Model:** generates expected loss cost for a given historical hurricane, or for a given type of storm affecting a given region.

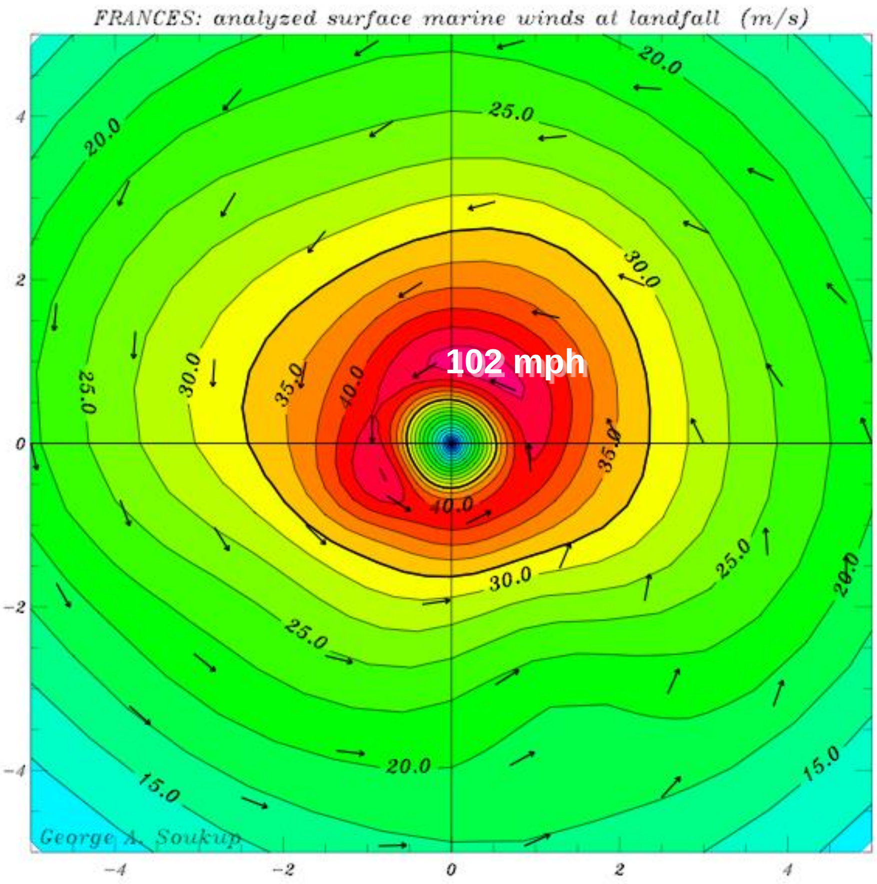
Output of the Meteorology Component

- 55,000 years of simulations generated stochastic set of over 45,000 hurricanes. Occur in over 20,000 years.
- Each simulated storm has an estimated track, intensity and wind fields at successive time intervals
- Wind field model generates open terrain 1 minute sustained wind speeds along the track
- These are corrected (downwards) for terrain roughness
- They are converted (upward) to 3 second peak gust winds
- For each zip code an accounting is made of all simulated hurricanes passing through
- Based on the pass through hurricanes and their peak winds at the zip code centroids, wind probability distribution are produced for each zip code.
- The wind probabilities are inputs into the actuarial model

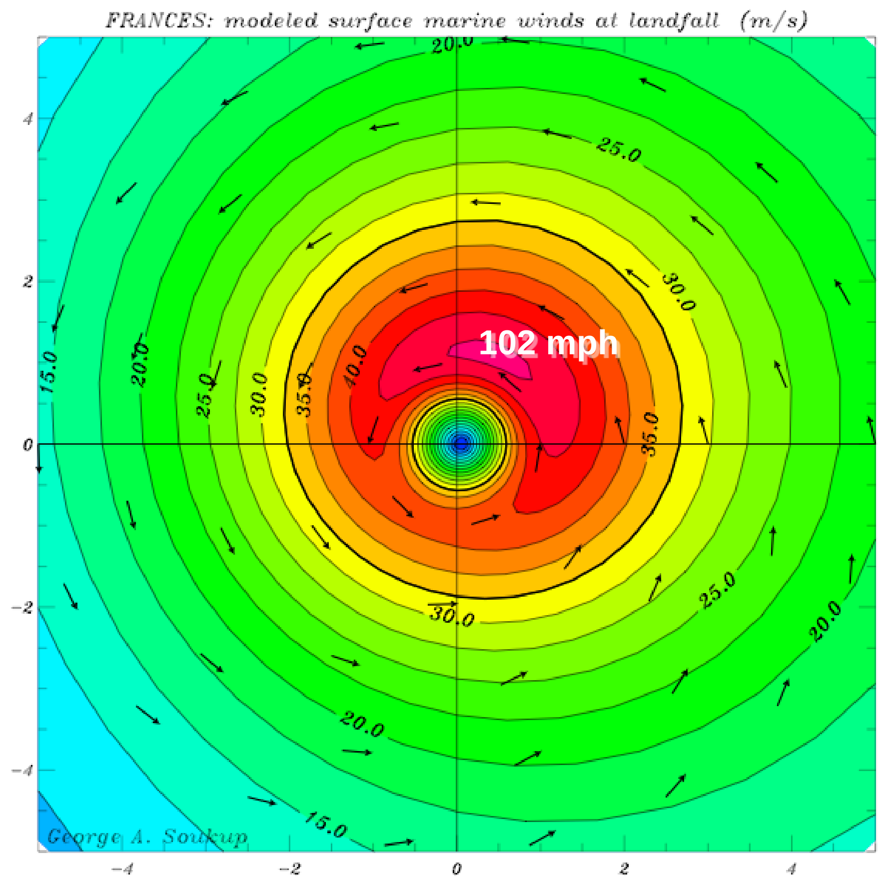
Number of land falling hurricane per year in Florida	Modeled probability
0	60%
1	26.7%
2	9.4%
3	2.8%
4	0.8%

Hurricane Frances Wind Field Validation

Observed



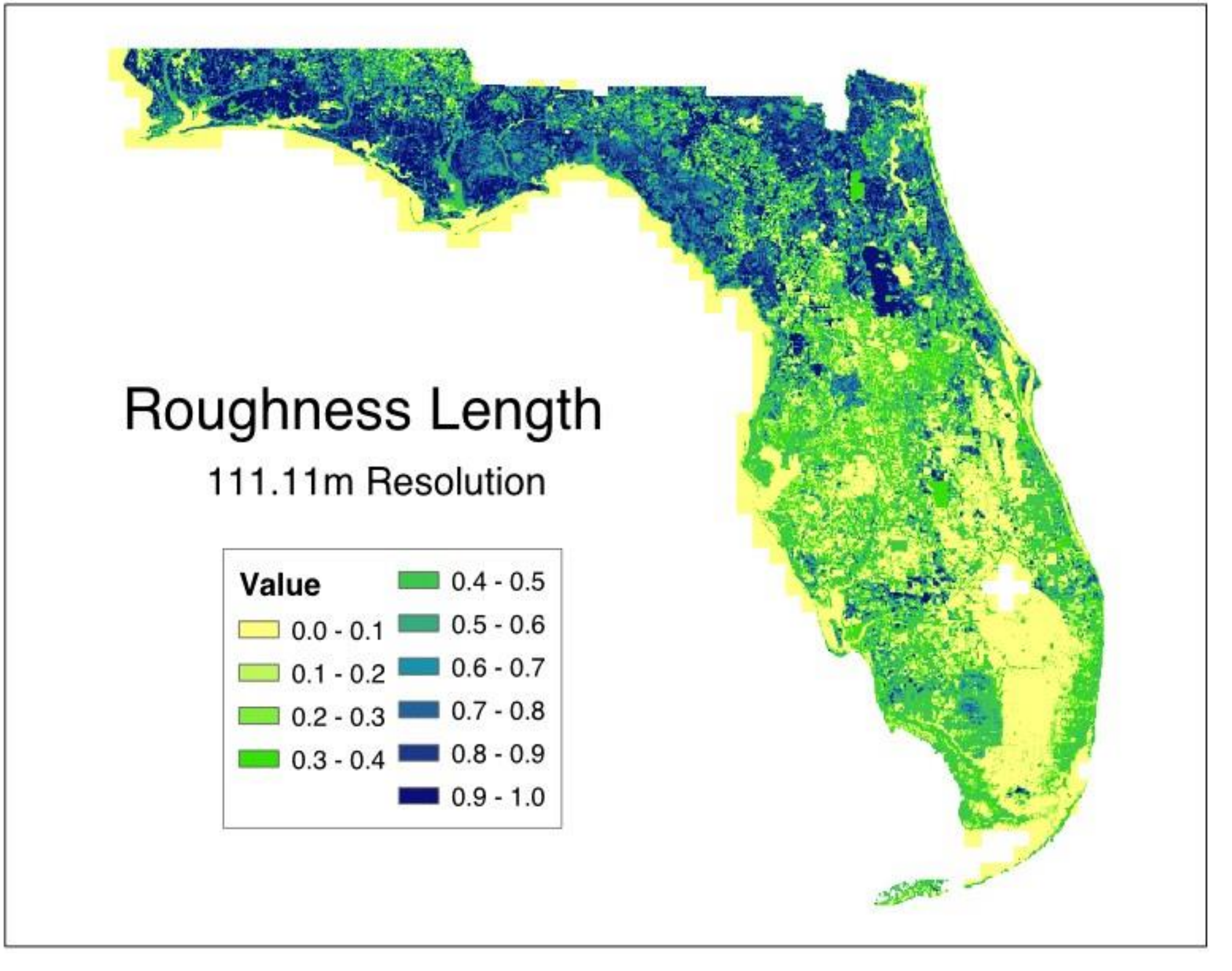
Model



Horizontal coordinates are R/Rmax

R/Rmax criterion OK

Effective roughness by taking into account upstream fetch from a zip code centroid in 45 degree octants



Engineering (vulnerability) component

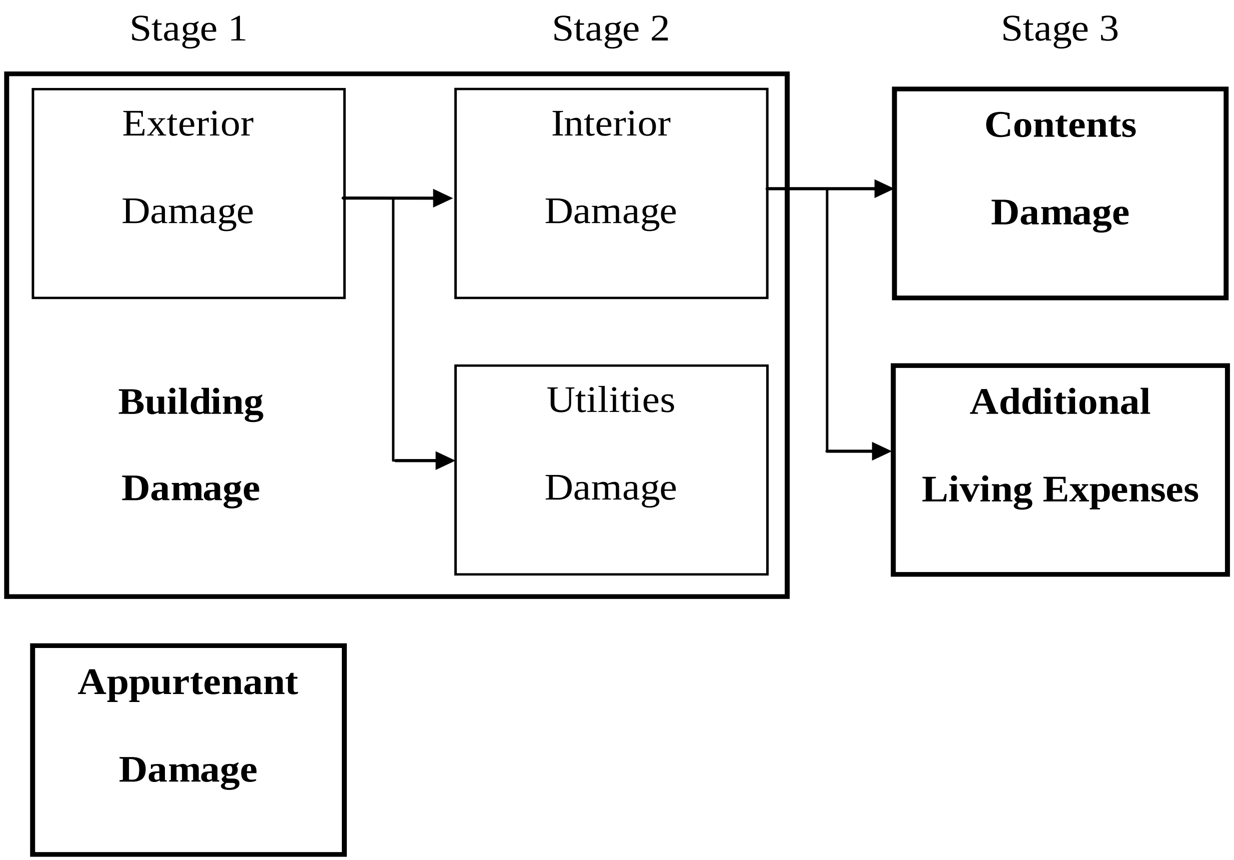
- Produces vulnerability matrices that are used as input into the actuarial model
- Separate vulnerability matrices are generated for each construction type (frame, masonry, mobile home, concrete high rise, unknown), roof type, 1 and 2 story, and quality of construction (strong, medium, weak)
- Separate matrices for north, central, south Florida and Keys regions
- Over 10,000 matrices and functions are created representing all the combinations of construction type and quality by region
- Separate matrices for building structure, contents, appurtenant structure and ALE.

Three stage engineering development process

- Stage 1: Use Monte Carlo simulation engine to simulate the physical wind damage to the exterior components (doors, windows, walls, roof cover, roof sheathing, roof to wall connection) over a range of winds.
- Relates probabilistic strength capacities of building components to deterministic 3-sec peak wind speeds
- Detailed wind and structural engineering analysis that includes effects of wind-borne missiles
- For each typical home, at each wind speed, 40,000 combined external damage states are generated (5,000 for each of 8 possible wind directions)

- Stage 2: Extrapolates the interior and utility damage from the exterior damage (includes damage from water penetration)
- Stage 3 : Extrapolates the content and ALE damage from the interior damage
- The 3 stage modeling process is repeated for each of the construction type and quality and region
- Model also computes damages to appurtenant structures (pool, deck, sheds, fence etc) based on empirical equations.

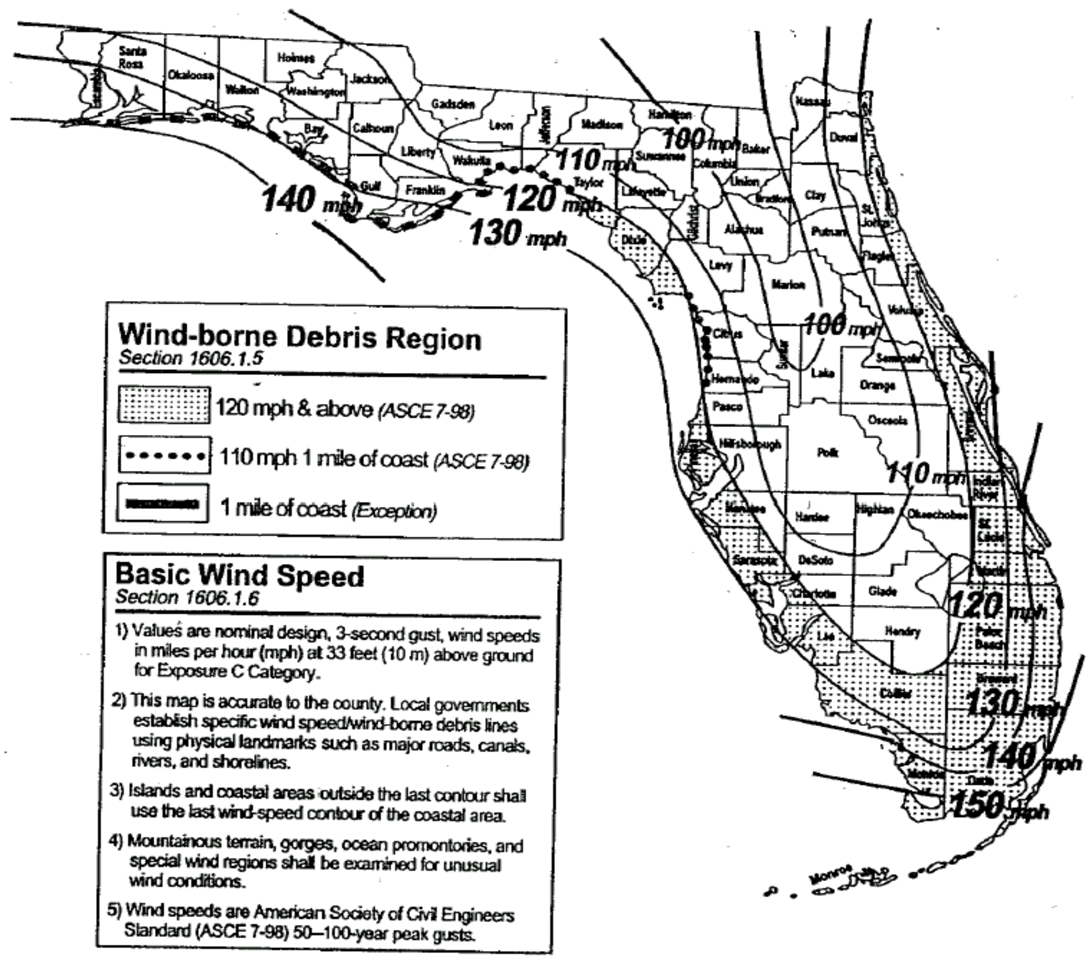
- The combined results of stages 1,2, and 3 produce a set of probability for various damage ratios (% of replacement cost)
- These are represented in a matrix form for personal residential model and vulnerability curve for commercial residential model
- For matrices the rows represent damage ratios in increments of 2%, the columns represent different wind speeds in 5 mph bins


Stage 1
Stage 2
Stage 3
Exterior Damage
Interior Damage
Contents Damage
Building Damage
Utilities Damage
Additional Living Expenses
Appurtenant Damage

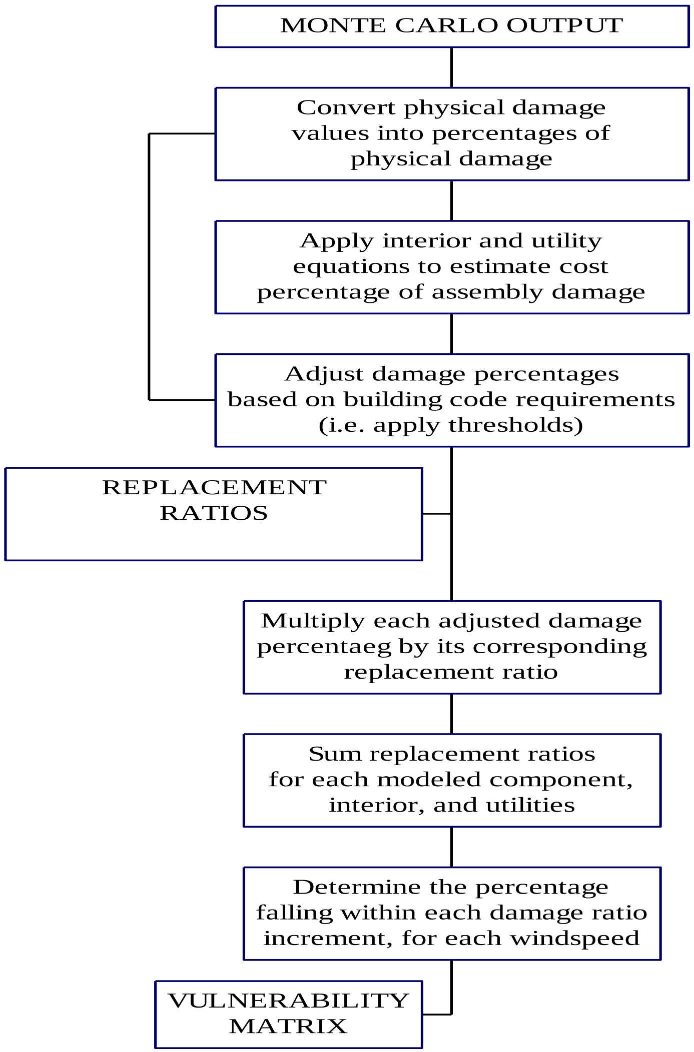
Building Code Issues

- High Velocity Hurricane Zone- Dade & Broward Counties (South Florida Bldg Code)
- Windborne Debris Regions- 1 mile from coast, or 120 mph basic wind-speed
- Under the Florida Building Code special conditions apply for repairs and alterations of existing structures in both of these regions
- Code open to interpretation

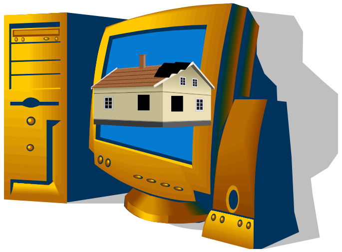
Building Code Issues: Wind Zones Map



CONVERTING PHYSICAL DAMAGE INTO THE VULNERABILITY MATRIX



Example Damage Matrix



- Partial sample of an output file for a concrete block home, in South FL, with a gable roof, and no hurricane shutters, subjected to a 150 mph 3-sec wind gust at an angle of 45 degrees

% failed Sheathing	% failed roof cover	% failed Connections	# failed walls	# of failed windows	# of failed doors	failed Garage (1=yes, 0=no)	Breach of Enveolpe (1=yes, 0=no)	# of failed windows by impact	% Gabel Ends Damaged
7.21	23.56	6.76	0.00	2.00	1.00	0.00	1.00	2.00	0.00
13.46	24.52	0.00	0.00	4.00	1.00	0.00	1.00	3.00	3.85
12.02	22.12	9.46	0.00	3.00	1.00	0.00	1.00	1.00	3.85
5.77	19.71	0.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00
9.62	25.00	0.00	0.00	2.00	1.00	0.00	1.00	1.00	0.00
6.25	15.87	0.00	0.00	2.00	0.00	0.00	1.00	1.00	3.85
7.69	23.08	4.05	0.00	5.00	1.00	0.00	1.00	3.00	11.54
10.10	26.92	0.00	0.00	3.00	1.00	0.00	1.00	2.00	0.00
7.21	24.52	0.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00
2.88	21.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.37	23.56	2.70	0.00	2.00	1.00	0.00	1.00	2.00	0.00
8.65	23.08	1.35	0.00	4.00	1.00	0.00	1.00	3.00	3.85
5.29	29.33	0.00	0.00	3.00	0.00	0.00	1.00	2.00	0.00

Damage Prediction

- Empirical equations determine the relationship between modeled external damage and:
  - unmodeled interior damage
  - Contents damage
  - Appurtenant structures
  - Additional Living Expenses (ALE)
- Assign costs to all damages
- Add all damages as a ratio of cost/ replacement value

Cost Estimating Resources (1)

- Collections of average unit costs for materials, labor, and equipment based on contractor bids for typical projects
  - CEIA Cost
  - RSMeans Residential Cost Data
  - National Construction Estimator
  - Marshall & Swift
  - Claim settlement info

Vulnerability Matrix

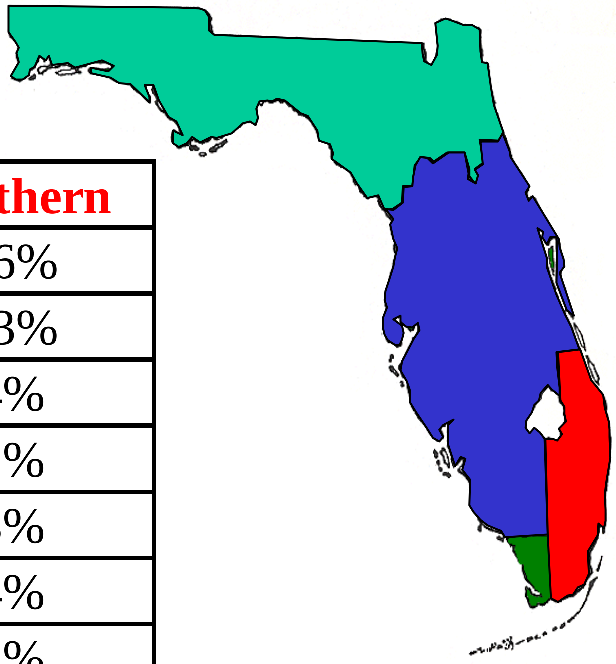
- Once the damage ratios are computed for each model simulation the probability of a particular damage ratio occurring is determined at each wind-speed

			Windspeed 3-sec gust (mph)						
Damage Ratio	**105**	**110**	**115**	**120**	**125**	**130**	**135**	**140**	**145**
0%	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1%	0.98	0.99	0.96	0.86	0.64	0.36	0.14	0.03	0.01
3%	0.00	0.01	0.03	0.12	0.27	0.39	0.39	0.26	0.12
5%	0.00	0.00	0.00	0.02	0.08	0.19	0.29	0.33	0.27
7%	0.00	0.00	0.00	0.00	0.01	0.06	0.17	0.30	0.40
9%	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.15
11%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03
13%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
15%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FL Residential Construction

Distribution of Building Types

Building Type	**Central**	**Northern**	**Southern**
CB G S/T	42%	12%	46%
CB H S/T	22%	6%	23%
Wd G S/T	12%	39%	4%
Wd H S/T	6%	20%	2%
CB G S/T 2	2%	1%	8%
CB H S/T 2	1%	0.4%	4%
Wd G S/T 2	1.4%	5%	1%
Wd H S/T 2	1%	2.3%	1%
Total Coverage	87%	86%	89%



FL Keys have unique construction style.

Resulting Classification

Roof Cover	Roof Type	**Exterior Wall**	Number of Story
Shingle	Gable	Wood frame	1
Tile - Metal	Hip	Masonry	2
Others	Other	Other	more

Evolution of Building Codes in Florida

- Building Codes in Florida evolved over time
  - 1946 to 1976: minimal wind loads provisions
  - 1976: first SBC wind speed map
  - 1982: SBC MWFRS and C&C
  - 1994: South Florida Building Code (post Andrew)
  - 2001: Florida Building Code and updates
- Building practice and code enforcement evolved over time
  - Enforcement widely varied in past decades
  - Post 1994 enforcement more reliable
- Building strength is assigned based on year built

Different Strength Models (Low-Rise)

- 3 sets of models for low rise, for each construction type (wood/masonry, hip/gable): weak, medium, strong.

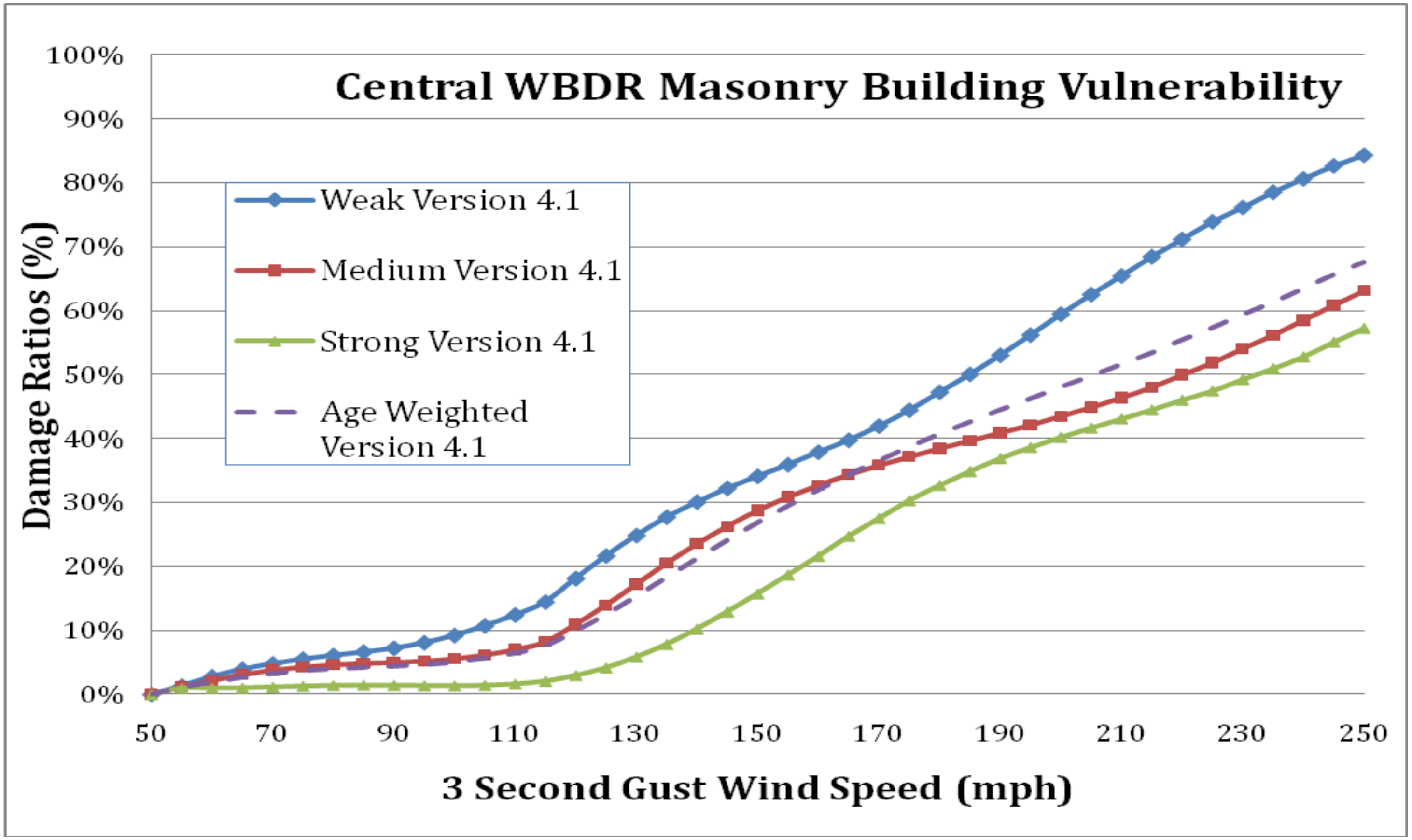
- Reflects different eras in building code development and practice while preserving the inherent uncertainties (e.g. actual roof shapes, local terrain effects, workmanship, enforcement, wind loads, etc.)

Variety of mid/high-rise buildings: 4+ stories mainly condominium buildings

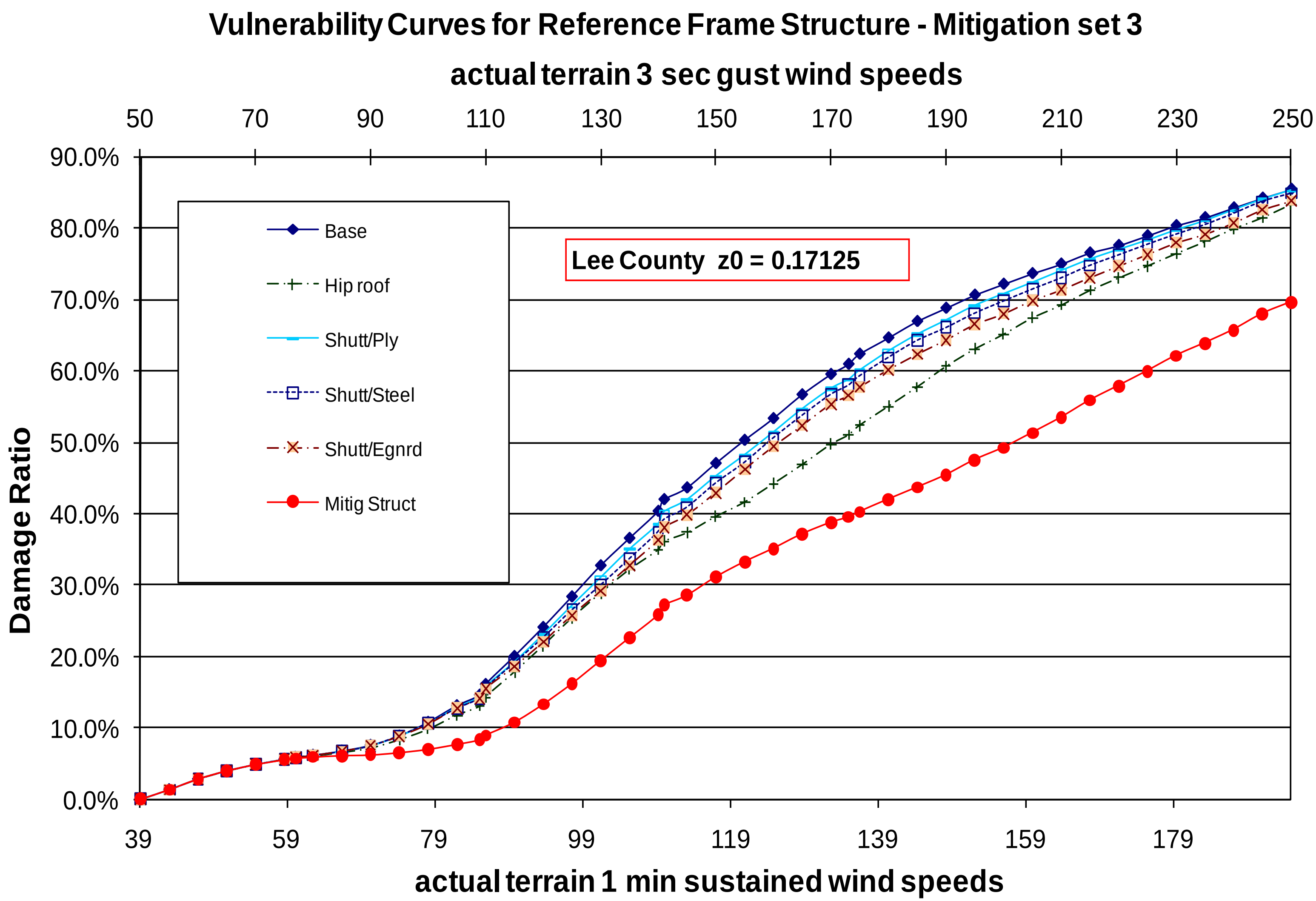
Mid-High rise Modeling

- Mid-High rise buildings are ***very different*** to single-family-homes
  - They are highly variable in shape, height, material, etc
  - Cannot be categorized in a few generic building types
  - Engineered structures that suffer little external structural damage and are unlikely to collapse
  - Can suffer extensive cladding and opening damage leading to water penetration and interior damage
  - FPHLM adopts a **modular approach : the building is treated as a collection of apartment units**

Selected Model Output

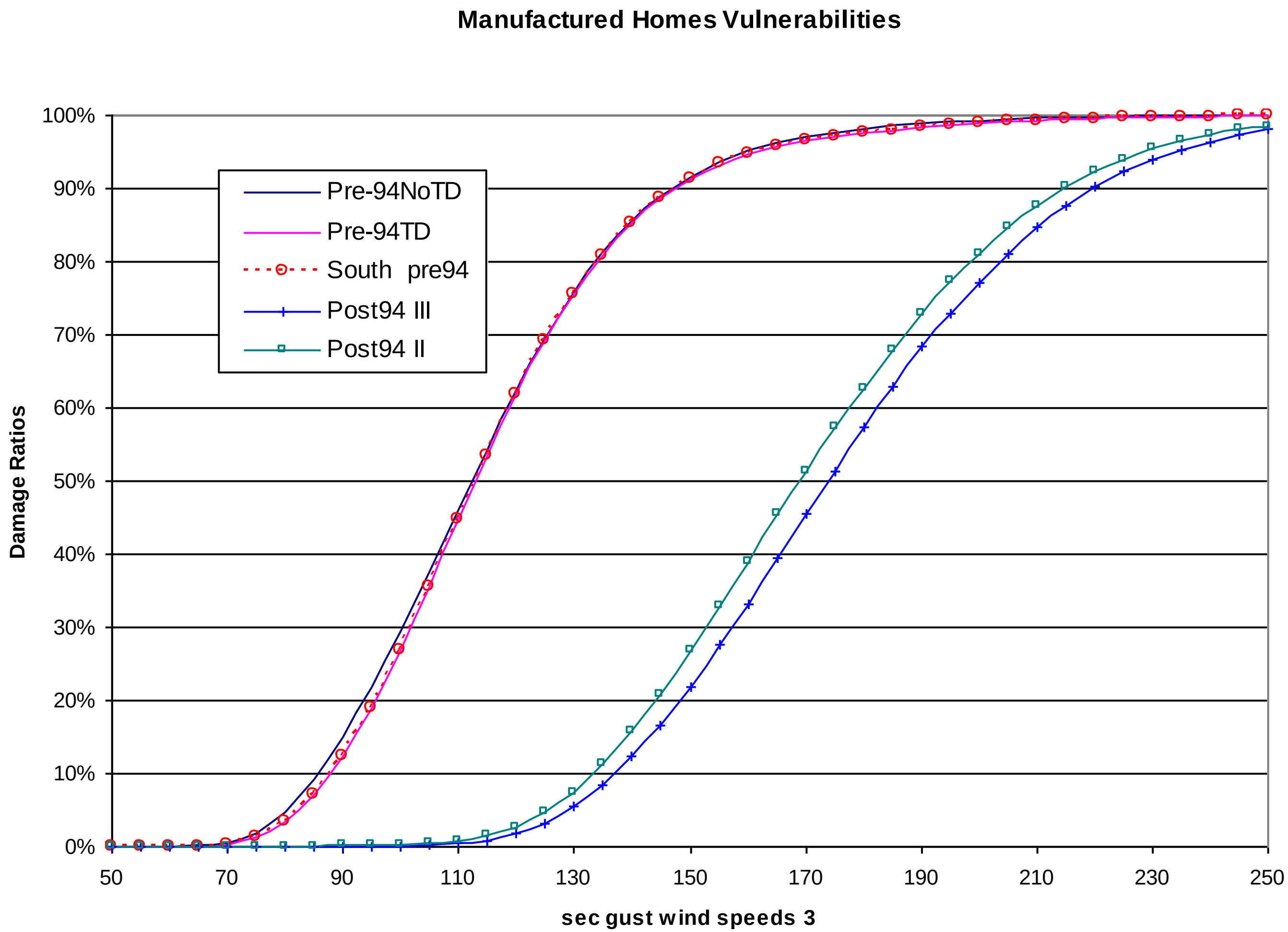


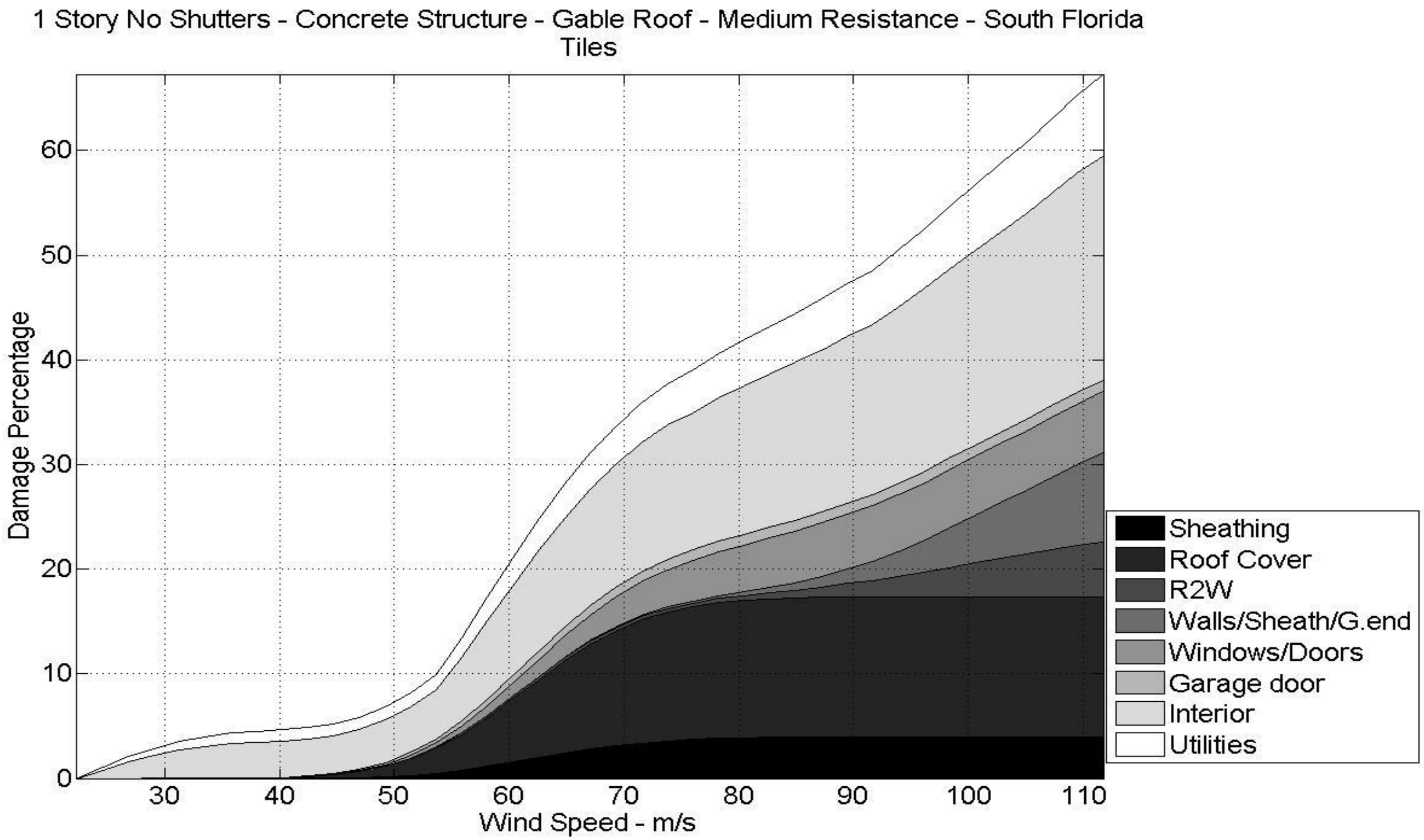
Weighted masonry structure vulnerabilities in the Central wind-borne debris region.



Vulnerability Curves for Reference Frame Structure - Mitigation set 3
actual terrain 3 sec gust wind speeds
50
70
90
110
130
150
170
190
210
230
250
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Damage Ratio
Base
Hip roof
Shutt/Ply
Shutt/Steel
Shutt/Egnrd
Mitig Struct
Lee County z0 = 0.17125
39
59
79
99
119
139
159
179
actual terrain 1 min sustained wind speeds

Manufactured Homes Vulnerabilities




1 Story No Shutters - Concrete Structure - Gable Roof - Medium Resistance - South Florida
Tiles
Damage Percentage
0
10
20
30
40
50
60
30
40
50
60
70
80
90
100
110
Wind Speed - m/s
Sheathing
Roof Cover
R2W
Walls/Sheath/G.end
Windows/Doors
Garage door
Interior
Utilities

Average Annual Loss
Based on Cat Fund exposure data

Personal Residential

- Zero deductible statewide AAL = $4.5 billion
- Net of deductible statewide AAL = $2.8 billion

Personal and Commercial Residential

- Zero deductible statewide AAL = $ 5.4 billion

Personal and Commercial Residential PML

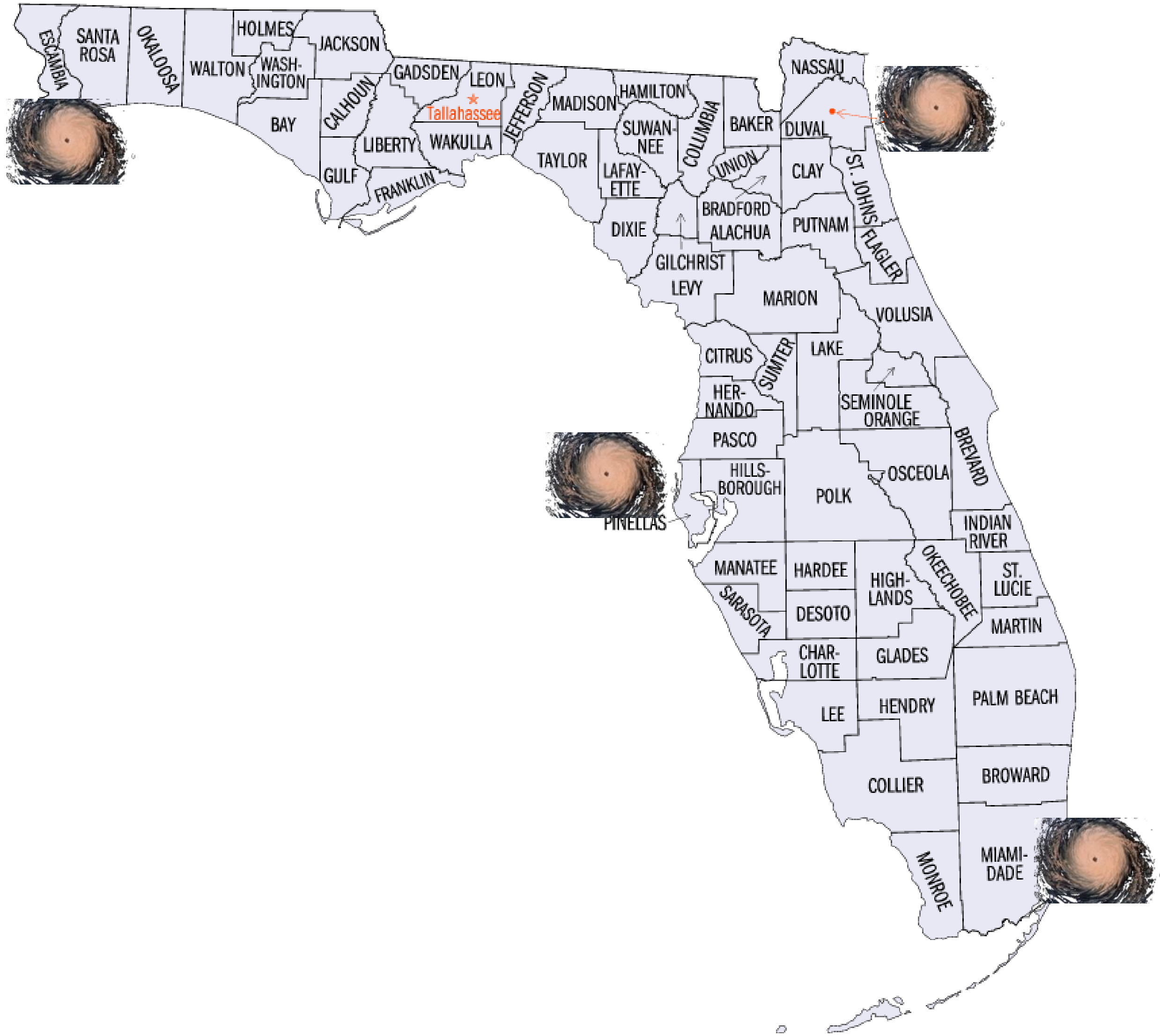
Return Period (Years)	Estimated Loss Level (Billions)
500	$83
250	$72
100	$59
50	$48
20	$32
10	$20
5	$7

What if scenarios

- One of the most speculated and debated issues is estimates of losses for “what if” scenarios.
- In particular, to properly understand the risks involved and to differentiate the vulnerability of different parts of the state, it is useful to estimate insured losses for hypothetical events in key locations such as Miami, Tampa, Jacksonville, etc.

Loss Estimates for Selected Hypothetical Events

- We estimated both zero deductible and net of deductible statewide losses for personal residential properties for some hypothetical events
- Events are Cat 1, 2, 3, 4, 5 hurricanes landing at 4 key locations in Florida: Jacksonville, Miami, Tampa, and Panama City
- The meteorological characteristics of a given category hurricane at landfall are held constant across all locations (same central pressure, radius of max winds, forward speed, direction at landfall)
- Hurricanes move inland at 90 degree direction to coastline until they exit the state
- Use the 2007 statewide exposure data provided by the Cat Fund (Zip code level data by coverage, construction type, and deductible group)


ESCAMBIA
SANTA ROSA
OKALOOSA
WALTON
HOLMES
WASH-INGTON
JACKSON
BAY
CALHOUN
GULF
LIBERTY
FRANKLIN
GADSDEN
LEON
Tallahassee
WAKULLA
JEFFERSON
MADISON
TAYLOR
HAMILTON
SUWAN-NEE
LAFAY-ETTE
DIXIE
COLUMBIA
BAKER
UNION
BRADFORD
ALACHUA
GILCHRIST
LEVY
NASSAU
DUVAL
CLAY
ST. JOHNS
PUTNAM
FLAGLER
MARION
VOLUSIA
CITRUS
SUMTER
LAKE
HER-NANDO
SEMINOLE
ORANGE
PASCO
BREVARD
HILLS-BOROUGH
PINELLAS
POLK
OSCEOLA
INDIAN RIVER
MANATEE
HARDEE
HIGH-LANDS
OKEECHOBEE
ST. LUCIE
SARASOTA
DESOTO
MARTIN
CHAR-LOTTE
GLADES
PALM BEACH
LEE
HENDRY
COLLIER
BROWARD
MONROE
MIAMI-DADE

Expected Insured Personal Residential Wind Losses for Given Simulated Hurricane Landfalls ($billion). Based on 2007 Exposure Data

Landfall Location		**Hurricane Category**				
		1	**2**	**3**	**4**	**5**
Jacksonville	Zero Ded	1.8	2.2	3.2	9.1	16.2
	Net of Ded	0.4	0.6	1.5	7.1	14.0
	% Diff	-78	-73	-53	-22	-14
	Peak Winds	99	109	133	168	190
Miami	Zero Ded	6.4	8.0	11.4	19.2	31.6
	Net of Ded	2.9	4.0	6.9	14.6	26.4
	% Diff	-55	-50	-39.5	-24	-16.5
	Peak Winds	100	111	141	168	188
Tampa	Zero Ded	10.3	12.7	18.5	35.0	50.0
	Net of Ded	4.8	6.8	12.3	28.4	43.6
	% Diff	-53.4	-46.5	-33.5	-19	-12.8
	Peak Winds	94	111	146	183	196
Panama City	Zero Ded	0.2	0.28	0.67	2.0	3.4
	Net of Ded	0.07	0.12	0.44	1.75	3.0
	% Diff	-65	-57	-34.3	-12.5	-11.8
	Peak Winds	83	95	115	147	165

- As expected, Tampa and Miami produce the highest personal residential losses and are the most vulnerable areas.
- Highest net of deductible losses are $43.6 billion produced by a Cat 5 hurricane landing in Tampa and going east (goes through the highly populated suburbs of Orlando)
- In contrast a Cat 5 landing at Miami will cause $26.4 billion net of deductible loss (afterwards goes west through the unpopulated Everglades)
- Losses increase exponentially with hurricane category
- Cat 5: 70% of loss is due to structure loss

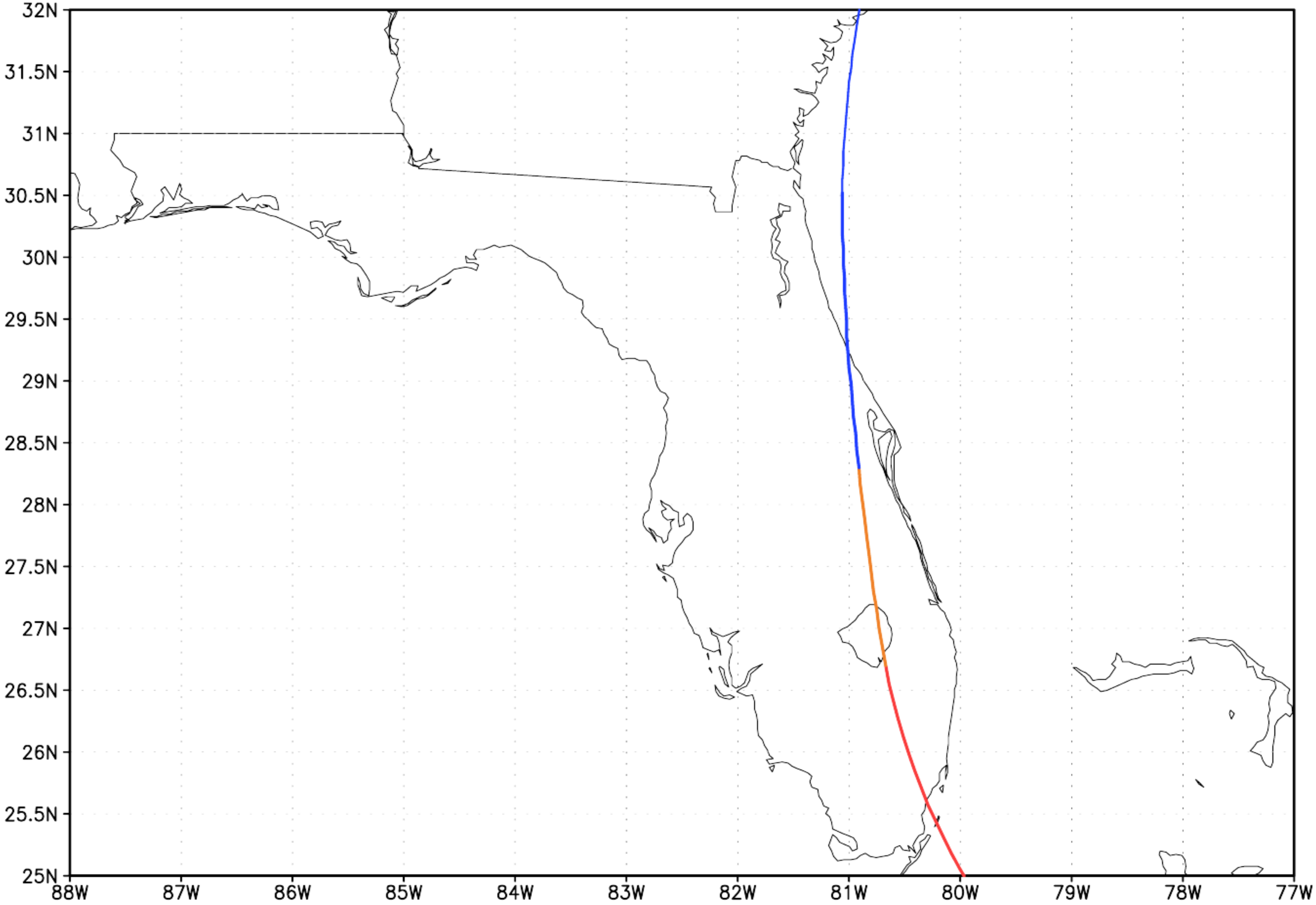
  Cat 1: 50% to 90% due to structure loss

Impact of hurricane deductibles

- Hurricane deductibles in Florida are controversial: increased from average of $250-$500 in the early 1990s to 2% to 5% of coverage now with higher property values.
- Current deductible structure reduce insured losses by 45% to 80% for the more frequent Cat 1,2 hurricane depending on location.
- Substantial reduction and major shift in burden to homeowners (likely requiring increased federal and state support)
- For Cat 5 hurricanes loss reduction range from 12% to 16%;   as expected burden will largely fall on insurance and reinsurance companies or the Cat Fund
- Because of change in mix of new and old, tougher building codes, the loss estimates have declined over recent years

Impact of terrain and topography

- It should be noted that in the simulations the meteorological characteristics of a given category of hurricane just before landfall over ocean were held identical across all locations.
- Thus, the differences in peak wind speeds at the different locations can be attributed largely to the coastal geography and terrain topology.
- It appears from the peak wind speed results that Miami (southeast Florida), Tampa (central west Florida) and Jacksonville (northeast Florida) have the terrain and topography to generate higher winds than the northwest or central west or southwest part of the state, and therefore, their topography is a source of higher risk and vulnerability.



Worst Case Scenario
(Large Cat 5 hurricane track)

Maximum Damage Reduction (%) Due to Mitigation Measures

	Masonry	Frame
• **Roof strength**		
– BRACED GABLE ENDS	1%	1%
– HIP ROOF	7%	10%
• **Roof Covering**		
– RATED SHINGLES (110 MPH)	1%	1%
– 8d NAILS	41%	41%
• **Wall-Floor Strength**		
– STRAPS	---	10%
• **Roof to Wall Strength**		
– CLIPS	13%	15%
– STRAPS	15%	22%

Maximum Damage Reduction (%) Due to Mitigation Measures

	Masonry	Frame
• **Wall-Foundation Strength**		
– VERTICAL REINFORCING	23%	---
• **Opening Protection**		
– PLYWOOD	7%	6%
– STEEL	11%	9%
– ENGINEERED	15%	13%
• **Window etc Strength**		
– LAMINATED GLASS	12%	11%
– IMPACT GLASS	15%	13%
• **Total Mitigated Structure**	**43%**	**44%**

Mitigation Discounts

Homeowner annual insurance premium for $300,000 masonry home in Miami (2012)

1992 built home (unmitigated)	$11,448
1992 built home (mitigated)	$5,364
2005 built home (new code)	$4,600