

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 \$4 trillion in insured properties of which about \$2.18 trillion are residential, and all are exposed to hurricane risk.
 - About 79% is coastal property which are particularly vulnerable to hurricane risk.
 - Of this \$400 billion in properties may be particularly vulnerable to storm surge.
 - About 35% of the flood policies and 30% of the flood premium originate in Florida.
 - Florida # residential HO policies 6.1 million
 - Only 18% of homes in Florida have flood insurance

- Starting with hurricane Andrew in 1992 Florida had a major crisis in the personal and residential property insurance market.
- The crisis became acute with the multiple hurricanes of 2004 and 2005
- Hurricane Sandy showed that even near Cat 1 hurricane can cause tremendous storm surge losses.
- There is great uncertainty about the nature of the risk and potential losses for the state and the insurance and reinsurance industries.
- Rates have increased dramatically with adverse impact on homeowners, businesses, mortgage industry, banks, and the real estate market.
- For a 1990 built house the average insurance premiums increased 683% between 1992 and 2012
- In 2006 in several polls of the residents of Florida HO insurance was cited as the second biggest concern
- Current paying capacity of FL property insurers is about \$60 billion

- In 2001 The Florida Office of Insurance Regulation funded Florida International University to independently develop a public hurricane loss model to assess hurricane wind risk and predict insured losses for these residential properties.
- First activated in March 2006. Latest version activated last September.
- Hurricane wind loss model has been used over 1,100 times by FL-OIR to evaluate rate filing .
- Model is used to conduct stress tests on insurance companies.
- Over 6 million insured homes are impacted
- Also been used by about thirty firms in the insurance industry.
- The wind model went through an extremely rigorous review process
 - Dozens of papers published in peer reviewed scientific journals and conference proceedings
 - Model is accepted by the Florida Commission on Hurricane Loss Projection Methodology----the gold standard for such models

Uses for the Florida Public Hurricane Wind Loss Model

- To help determine actuarially sound pricing of homeowner insurance for hurricane risk.
- To help determine risk and losses for buildings, contents, and ALE
- Model outputs are used by the state to evaluate rate filings by insurance companies. All companies that request rate changes are processed through the model.
- To determine premium discounts for mitigation features in the residential structures.
- To help conduct stress tests on insurance companies. Help evaluate their solvency under various hurricane catastrophe scenarios
- To conduct scenario analysis

- In 2013 the state funded FIU to enhance the FPHLM by adding both a storm surge and fresh water flooding component (hurricane related and other floods).
- The enhancement project will come up with a proto type soon.
- Pricing of flood insurance is becoming a contentious issue both at the state and federal level
- Model will estimate risk and probable losses and help determine fair and actuarially sound pricing for Florida
- The FCHLPM has drafted standards for the flood model, Model will meet the commission standards.

Participating Institutions

- Florida International University/ IHRC (lead institution)
- Florida State University
- University of Florida
- Florida Institute of Technology
- Hurricane Research Division, NOAA
- University of Miami
- Notre Dame University
- West Virginia University

- Over 30 professors and experts and over 75 graduate and undergraduate students have been involved in the development and operation of the model.
- The collection of specialized expertise working on the FPHLM is of the highest quality.
- 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 model was developed independently from FL-OIR

The current and past key team members

- Dr. Shahid Hamid Dept of Finance and IHRC, Florida International University
- Dr. Shu-Ching Chen School of Computing and Information Sciences, FIU
- Dr. Keqi Zhang Dept. Environ Studies/ Int Hurricane Research Center, FIU
- Dr. Jean Paul Pinelli Dept of Civil Engineering, Florida Institute of Technology
- Dr. Steven Cocke Dept of Meteorology, Florida State University
- Dr. Kurtis Gurley Dept of Civil and Coastal Engineering, Univ of Florida
- Dr. Mark Powell Hurricane Research Division, NOAA
- Dr. Fausto Fleitis School of Computing and Information Sciences, FIU
- Dr. TN Krishnamurti Dept. of Meteorology, FSU
- Dr. Emil Simiu NIST and John Hopkins University
- Dr. Omar Abdul-Aziz Hydrologist, Dept of Civil Eng, Univ of West Virginia/FIU
- Dr. Andrew Kennedy Coastal Engr, Dept of Civil Engr, University of Notre Dame
- Bachir Annane CIMAS, University of Miami
- Dr. Mei-Ling Shyu Dept of Electrical and Comp Engineering, Univ of Miami
- Gail Flannery FCAS Actuary, Vice- President AMI Risk Consultants
- Bob Ingco FCAS Actuary, AMI Risk Consultants

The current and past key team members

- Raul Garcia School of Comp and Info Sciences and IHRC, FIU
- Diana Machado School of Comp and Info Sciences and IHRC, FIU
- Dr. George Soukup Applied physicist, AOML/NOAA
- Neal Dorst Hurricane Research Division, NOAA
- Dr. Yuepeng Li International Hurricane Research Center, FIU
- Dr. Sneh Gulati Department of Statistics, FIU, statistical expert
- Dr. B. G. Kibria Department of Statistics, FIU, statistical expert
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- Dr. Huiqing Liu International Hurricane Research Center, FIU
- Dr. Yongzhi Liu Dept of Civil Engineering, Florida International University
- Dr. Mani Subramaniam Dept of Mech Engineering, FIT
- Dr. Min Chen Computer Science, FIU/ Univ of Montana
- Dr. Na Zhao Computer Science, FIU
- Dr. Hsin-Yu Ha School of Comp and Info Sciences and IHRC, FIU
- Nirva Morisseau Database expert, HRD, NOAA
- Dr. Duong Nguyen Dept. of Finance, FIU and U-Mass Dartmouth

Pre-Andrew Econometric Models

- Belief whole hurricane hazard situation lay exclusively within the actuarial field and could be managed with actuarial information alone
- Relied up to the 1990's solely on recent historical claim data and actuarial based econometric model
- Model predicted **\$80 million** for 1992 clearly less than the **\$16 billion** insured losses that Andrew caused
- Such actuarial models can cause wild swings in premiums
- Needed multi-disciplinary computer model

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.

What can the wind model produce?

- The model can generate for a given policy or portfolio of residential policies, the annual average losses and the probable maximum losses
 - Loss estimates are produced for building structures, contents, and additional living expense coverage
 - These are typically used by insurance companies as input in the rate making process and are used by state regulators to help evaluate rate filings
- Model 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.
- Model can conduct stress test on insurance companies to assess solvency in case of catastrophe.

What will the storm surge enhancement do?

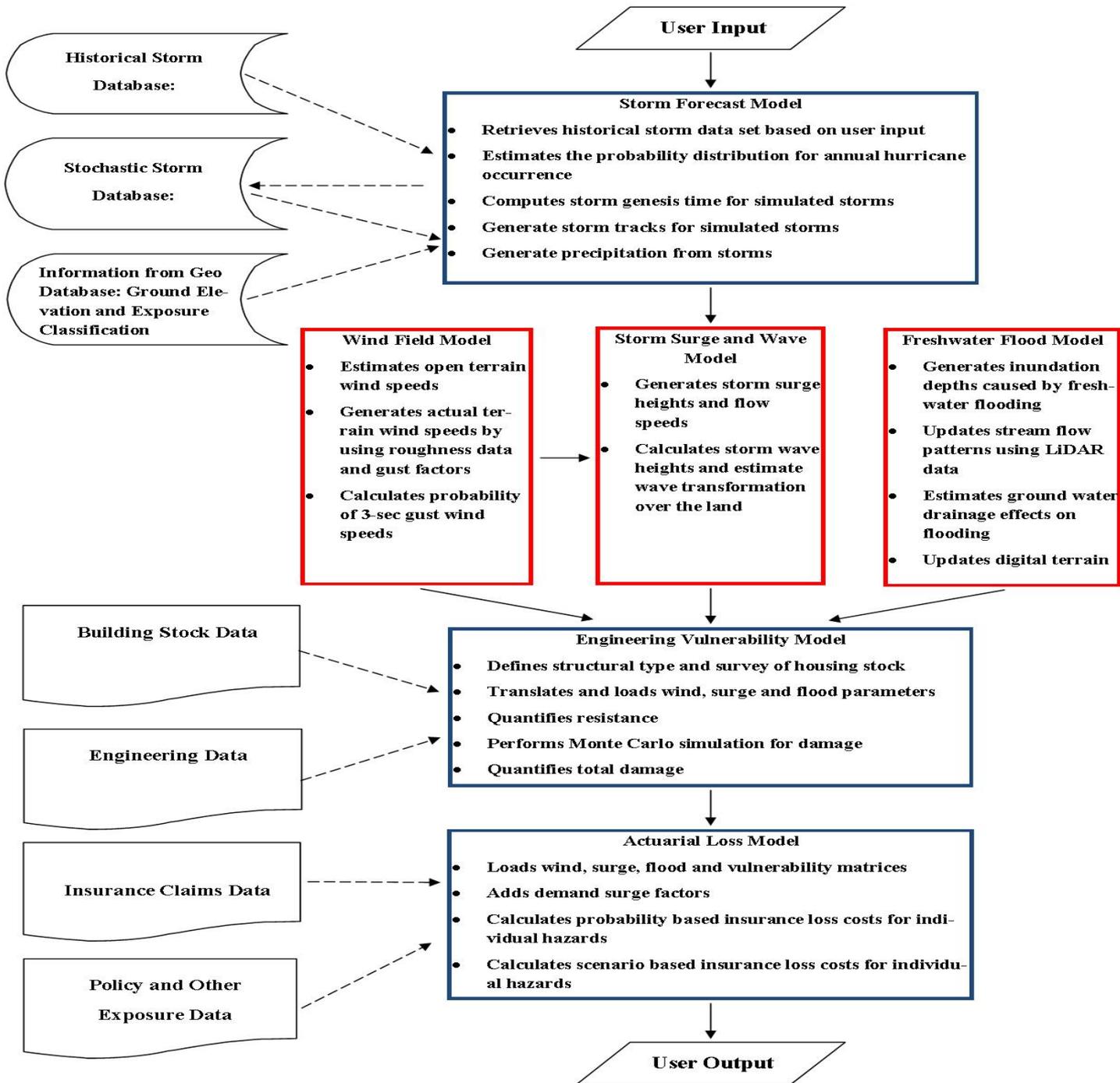
- The new components will assess storm surge and inland flood risk and estimate losses they may create.
- provide a more refined and actuarially sound method of estimating insured losses and determining fair pricing for all sources of hurricane risk (for consumers and insurers)
- conduct simulations and scenario analysis that can help state and local government with disaster planning and land use planning
- Help assess the cost-benefit of disaster mitigation strategies

Components of the existing wind model

- Hurricane threat area definition
- Storm genesis model
- Storm Track and Intensity Model
- Inland Storm Decay Model
- Wind Field Model
- Terrain Roughness Model
- Gust Factor Model
- Wind Probabilities Model
- GIS component
- Engineering damage simulation models
- Engineering vulnerability model
- Engineering Mitigation Model
- Demand Surge Model
- Probabilistic Loss Cost Actuarial Model
- Scenario based Loss Cost Actuarial Model
- Extensive survey was conducted of the building stock in Florida. Identified key structure types and combination of features

New components of the Storm Surge and Flood Model

- Wind and storm surge temporal and spatial interpolation model
- Coastal basin size determination
- Storm surge inundation model
- Ocean wave model
- Near shore wave transformation model
- Freshwater hydrological flood model
- Drainage model for flood
- Engineering vulnerability simulation models for storm surge and wave
- Engineering vulnerability simulation models for inland flood
- Engineering damage models for surge and wave
- Engineering damage models for inland flood
- Probabilistic ground up and actuarial loss model for surge and flood
- Scenario based loss model for surge and flood
- Mitigation model for surge and flood
- GIS overlay model for surge and flood
- These components are being tested and validated
- Software is being developed and tested for these components



Meteorology Components

- Storm Track Generator
- Wind Model
- Terrain Adjustment

Storm Track Generator

- Storm seeds based on historical storms that entered a threat area surrounding Florida and neighboring states
 - Initial position started at the historical position of the storm 36 hours prior to entering threat area, plus uniform random perturbations
 - Initial speed and intensity based on historical data plus random perturbations
- Changes in speed, direction and relative intensity are sampled from empirical PDFs derived from HURDAT data, and random perturbations added
- Storm parameters (R_{max} and Holland B) are sampled from distributions derived from historical data

Storm Track Generator

- When storm is over land, a pressure filling model is used (exponential decay in time). If storms re-enters water, intensity changes are again resampled from the PDFs derived from HURDAT.
- Storms seeds are reused, but with new random perturbations, to generate about 57,000 years of storms
- Storm tracks are in 1 hr increments, and includes position, intensity (pressure), date and storm parameters (Rmax, B)
- Storm terminates when it exits domain or central pressure exceeds 1011 mb

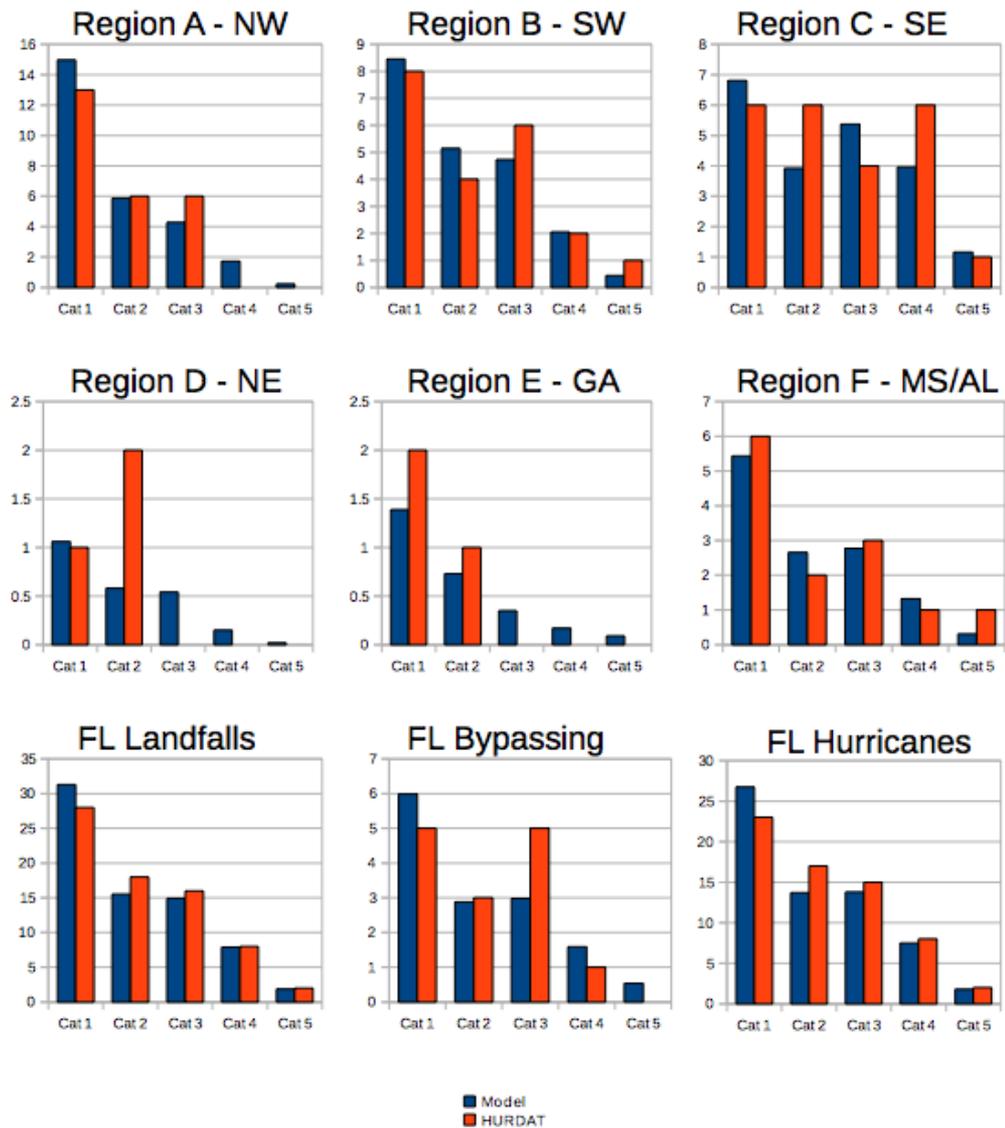
Model Domain



Sample Stochastic Tracks

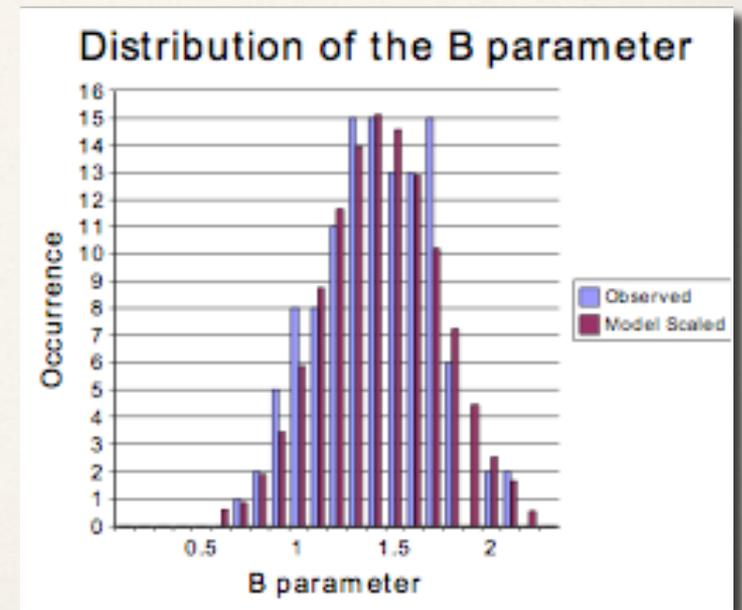
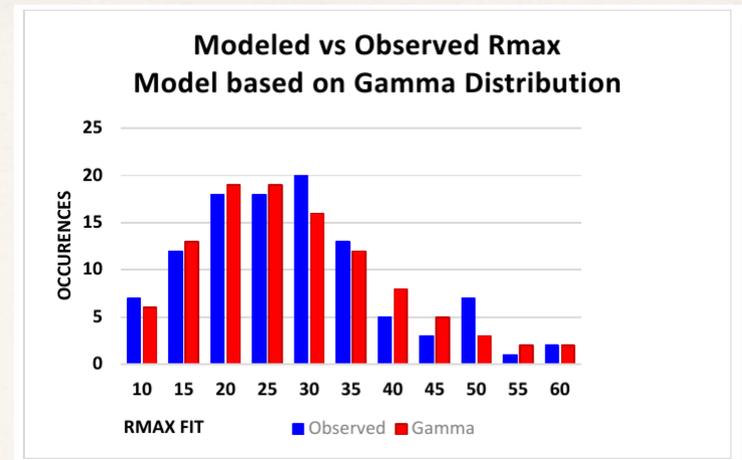


- Landfall by SS Category and Region

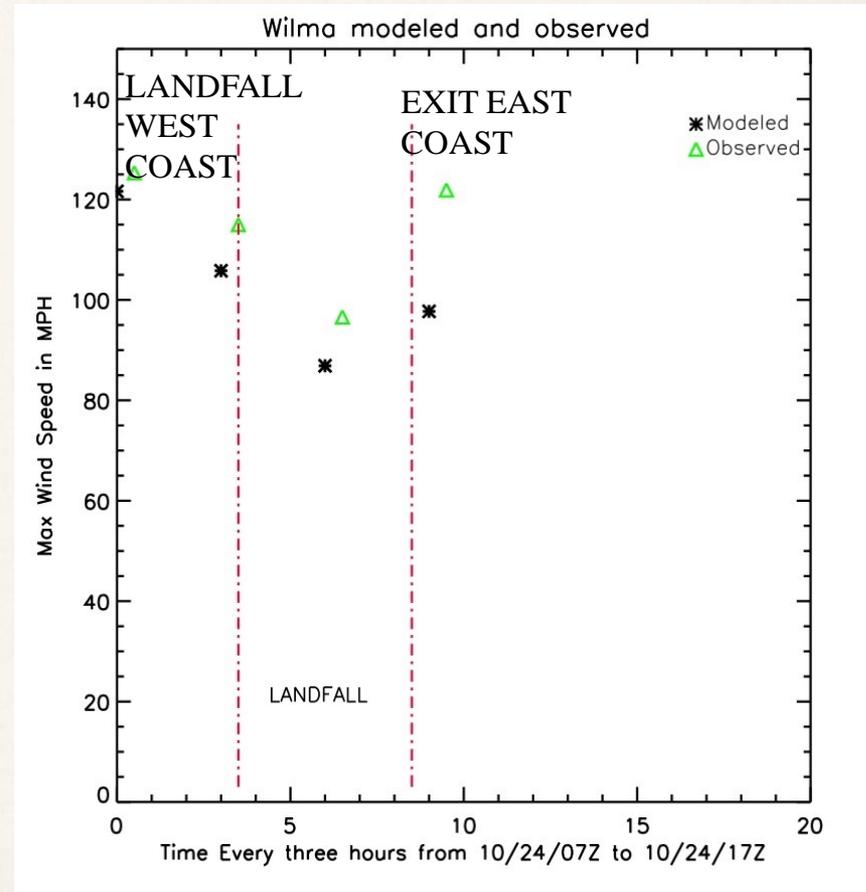
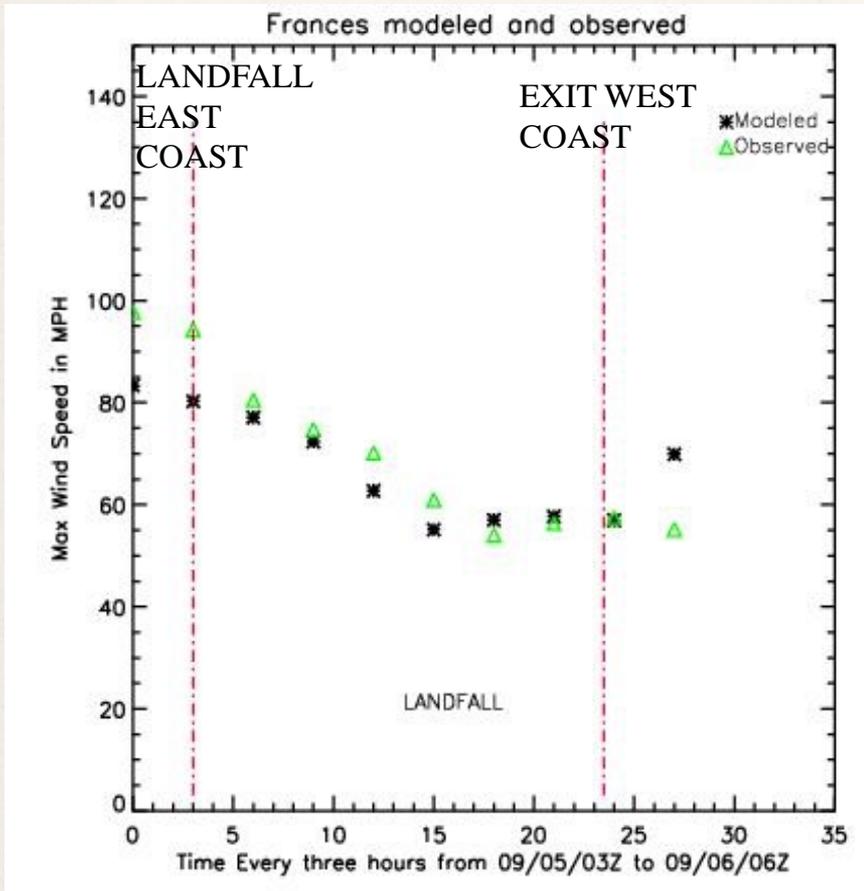


Storm Parameters

- Rmax modeled by Gamma distribution
- Holland B modeled by linear regression with residual fitted by a Gaussian distribution



Landfall decay



Wind Model

- Numerical solution of a “slab” model of the hurricane boundary layer, 450 m deep over ocean, 1 km deep over land (see Powell et al, 2005)
- Includes surface friction, with different drag coefficient over land vs water. Based on GPS sonde data.
- Initialized by a vortex in gradient balance with pressure field described by a Holland B profile.
- Mean wind of the slab is converted to a surface wind based on GPS sonde research

- **Wind field validation**

- 9 Hurricanes:

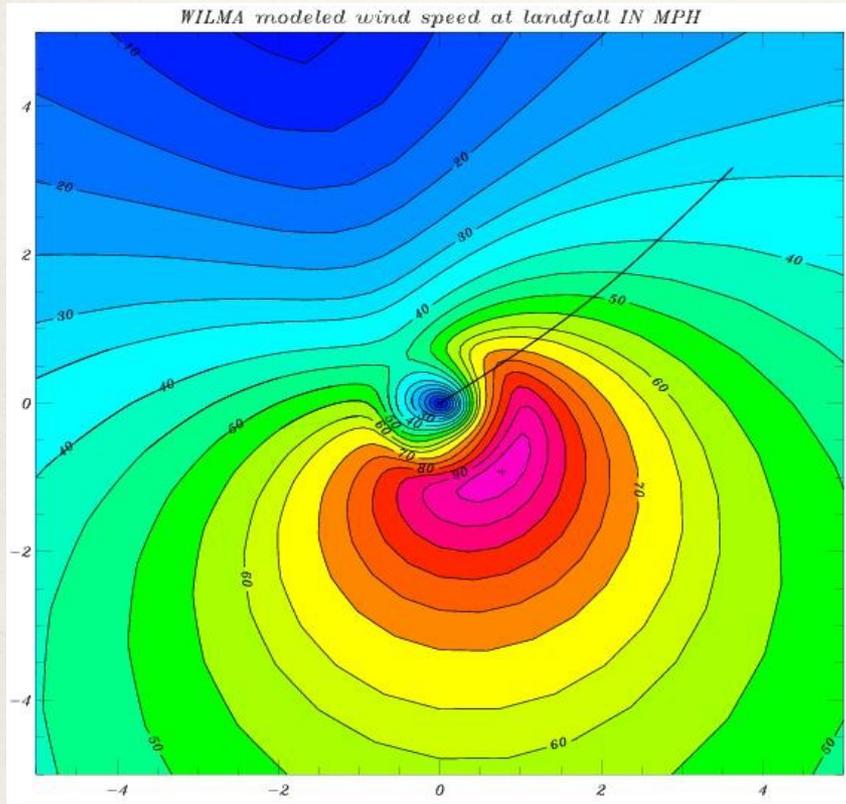
- 1992 Andrew

- 2004 Charley, Frances, Ivan, Jeanne

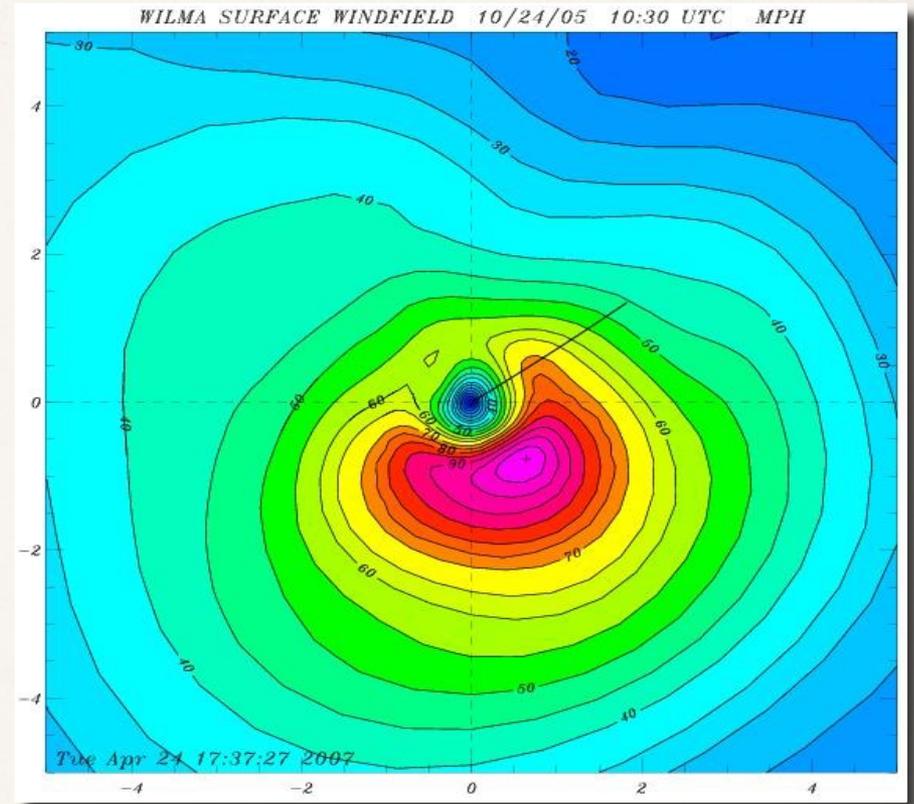
- 2005: Dennis, Katrina, Rita, Wilma

MODEL VS H*WIND snapshot

WILMA MODELED

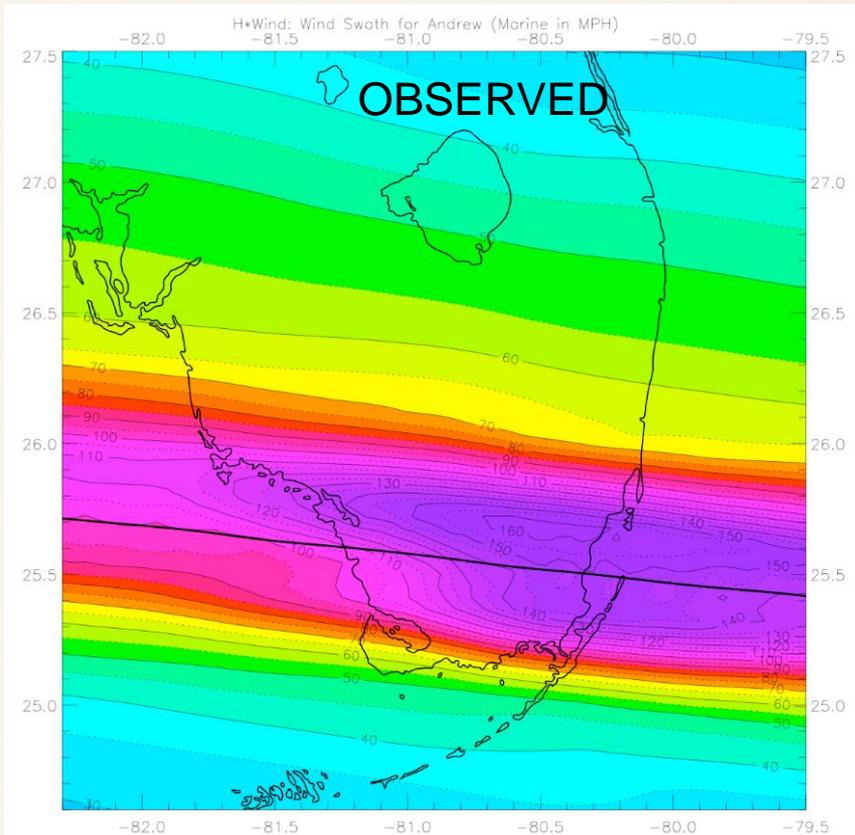
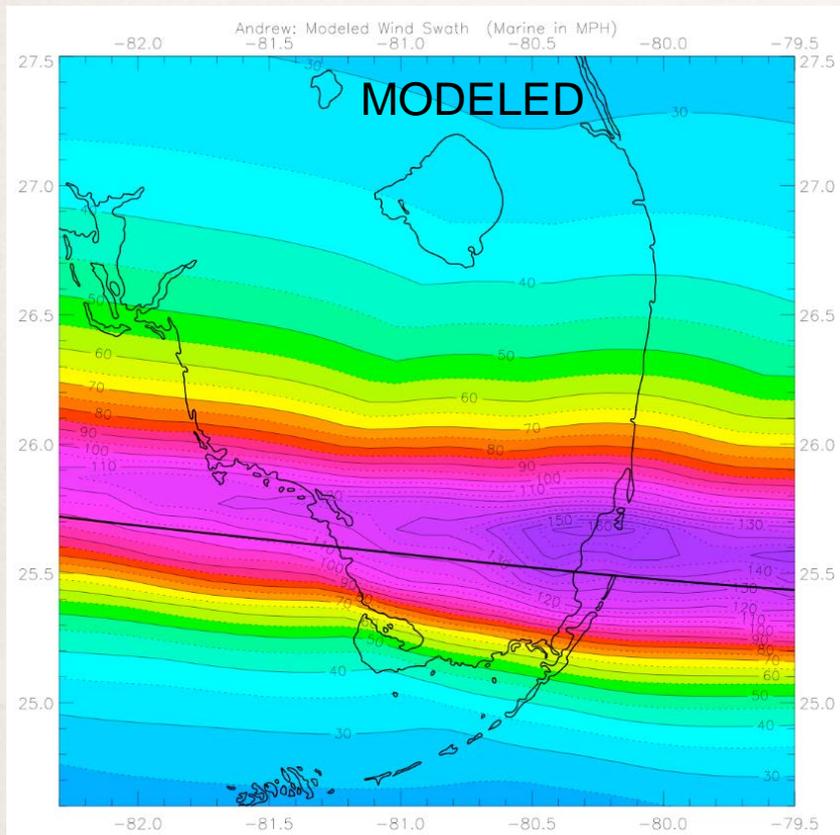


WILMA OBSERVED



MODEL VS H*WIND SWATH

ANDREW



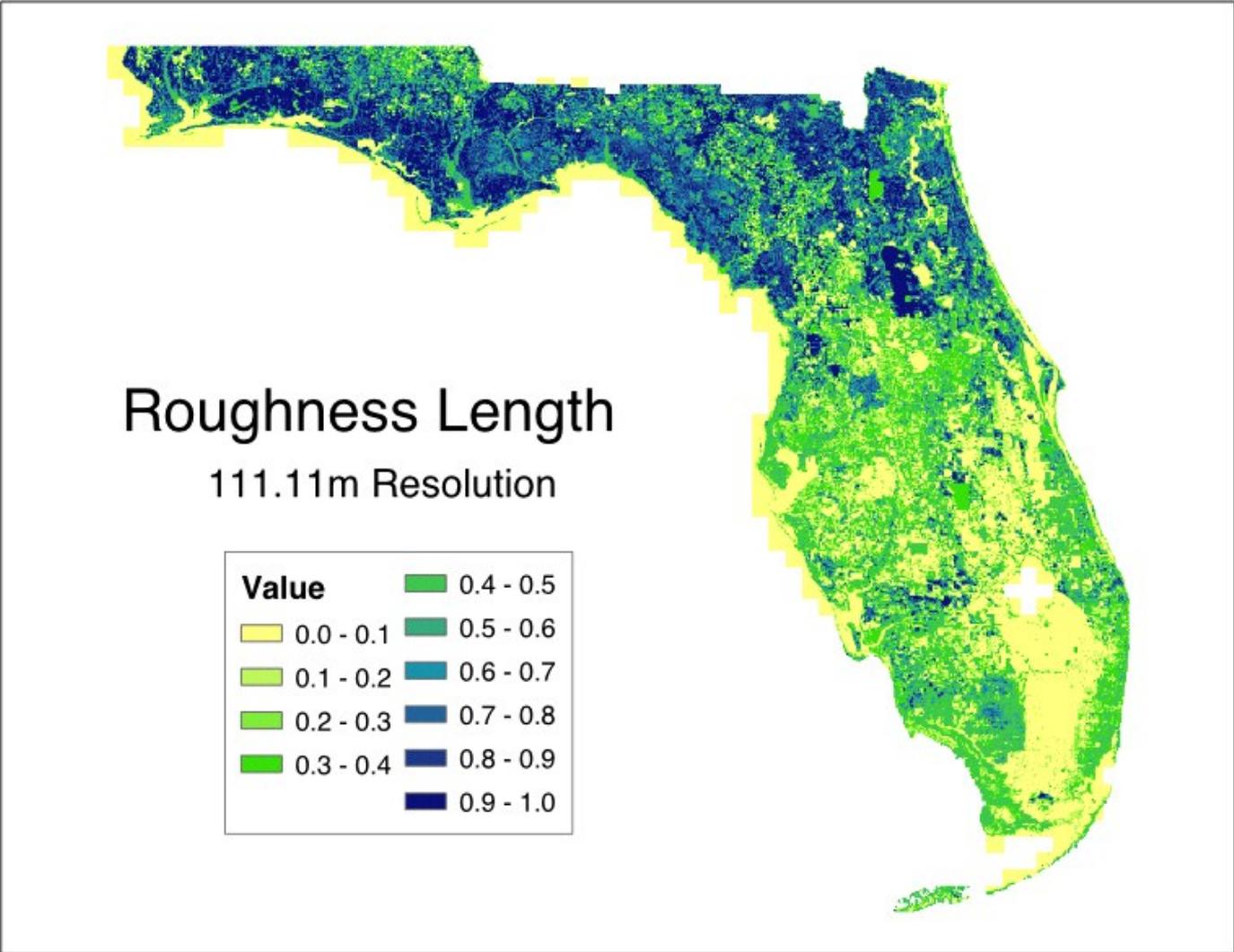
Terrain Adjustment

- Winds are adjusted to terrain conditions using an effective roughness model and a coastal transition function for locations near the coast
- The effective roughness model determines the effect on roughness due to upstream land cover elements in each 45 degree sector.
- Effective roughness is computed at roughly 90 m resolution over Florida. For ZIP code policies, the roughness used is the population weighted effective roughness over the ZIP code.
- Roughness derived from 2011 National Land Use / Land Cover plus Florida Water Management District data (2004-2011)
- Over 29 million grid roughness estimated
- For locations near the coast, a coastal transition function is used to account for the transition of the wind being in equilibrium with marine roughness to subsequently being in equilibrium with land roughness.
- Gust factor model based on ESDU is used to determine 1 minute sustained and 3 second gusts

Output of the Meteorology Component

- 57,000 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 grid an accounting is made of all simulated hurricanes passing through and their peak gust wind
- The peak winds are input into the vulnerability and actuarial model

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

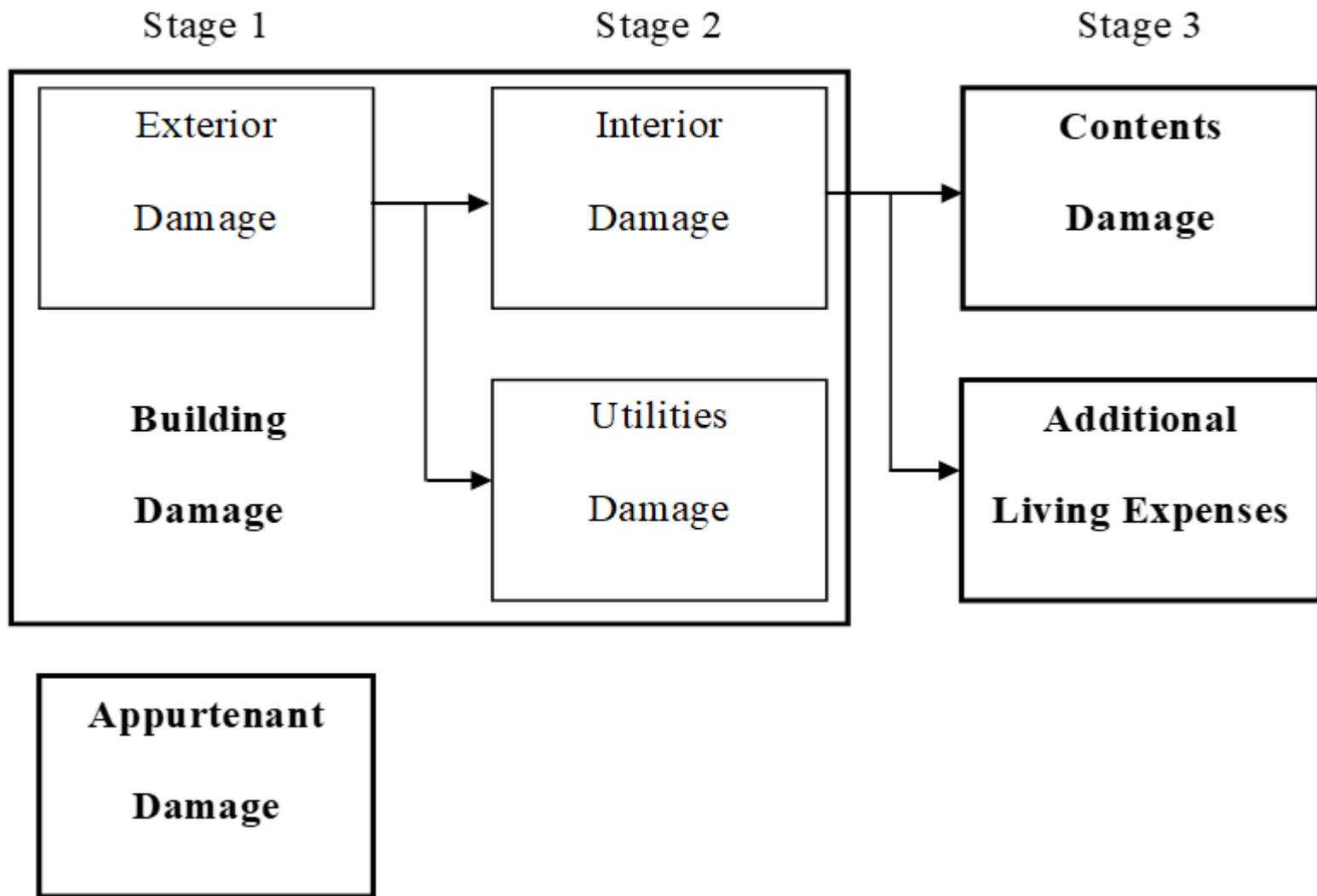


57,000 years of simulations - stochastic set of over 45,000 hurricanes

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

Engineering (vulnerability) component

- Produces vulnerability functions (matrices) that are used as input into the actuarial model
- Three model
 - personal residential
 - low rise commercial residential
 - mid-high rise commercial residential
- 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.



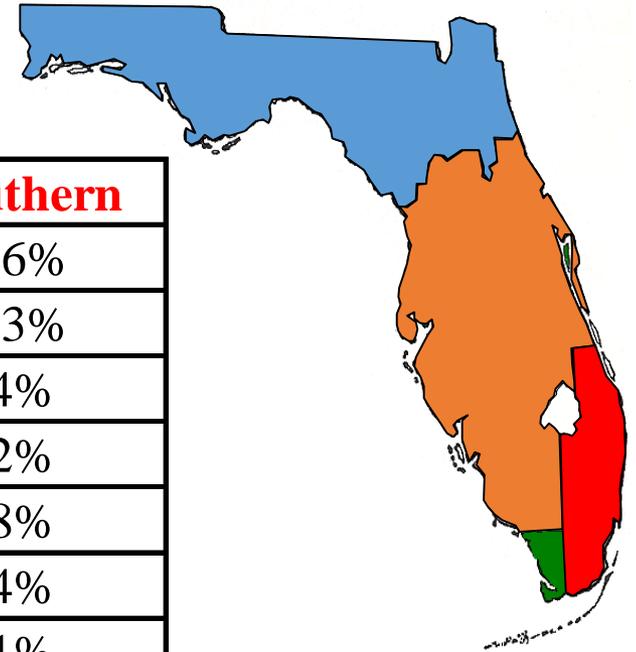
Evolution of Building Codes in Florida

- 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

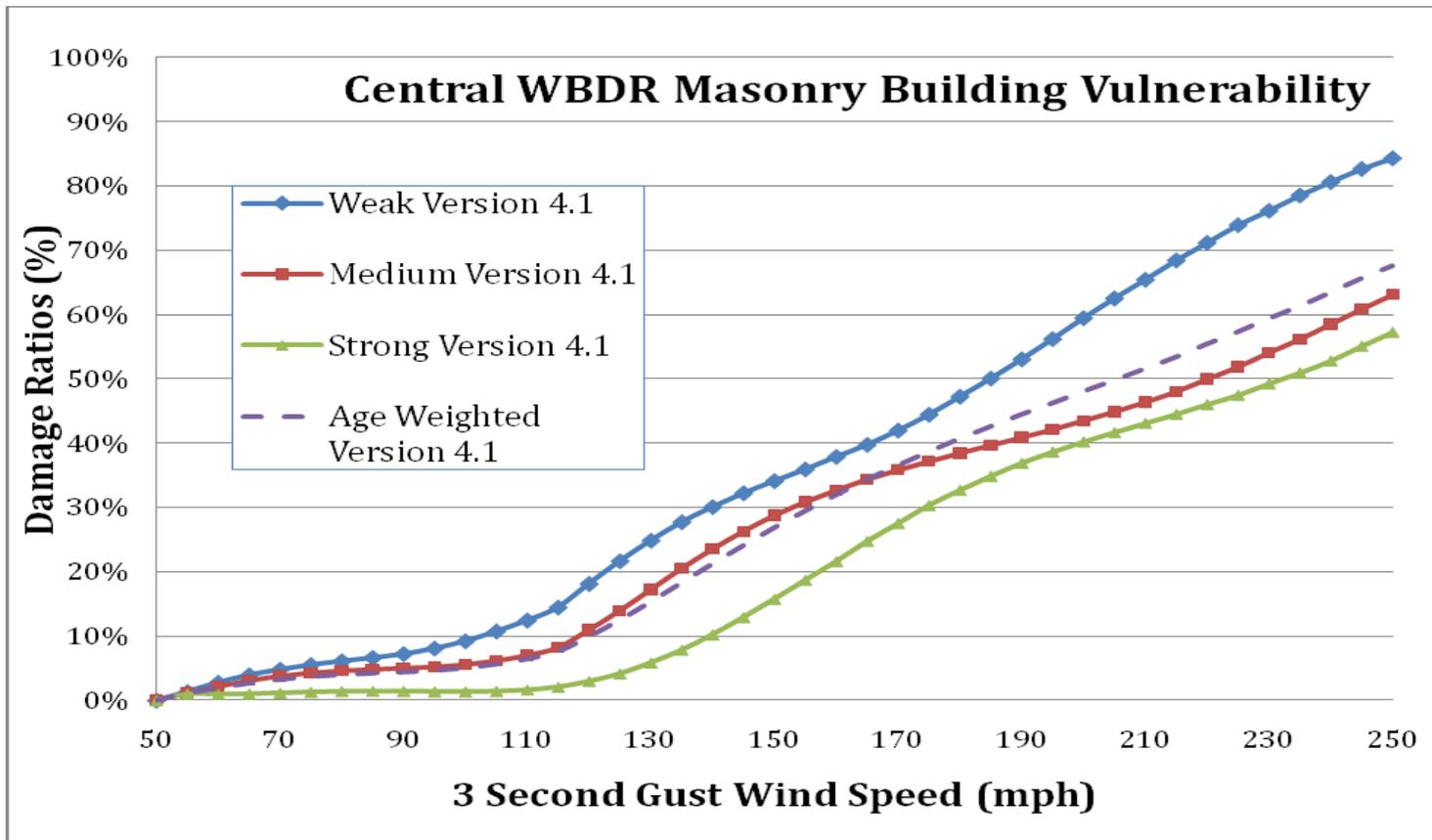
FL Residential Construction

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%



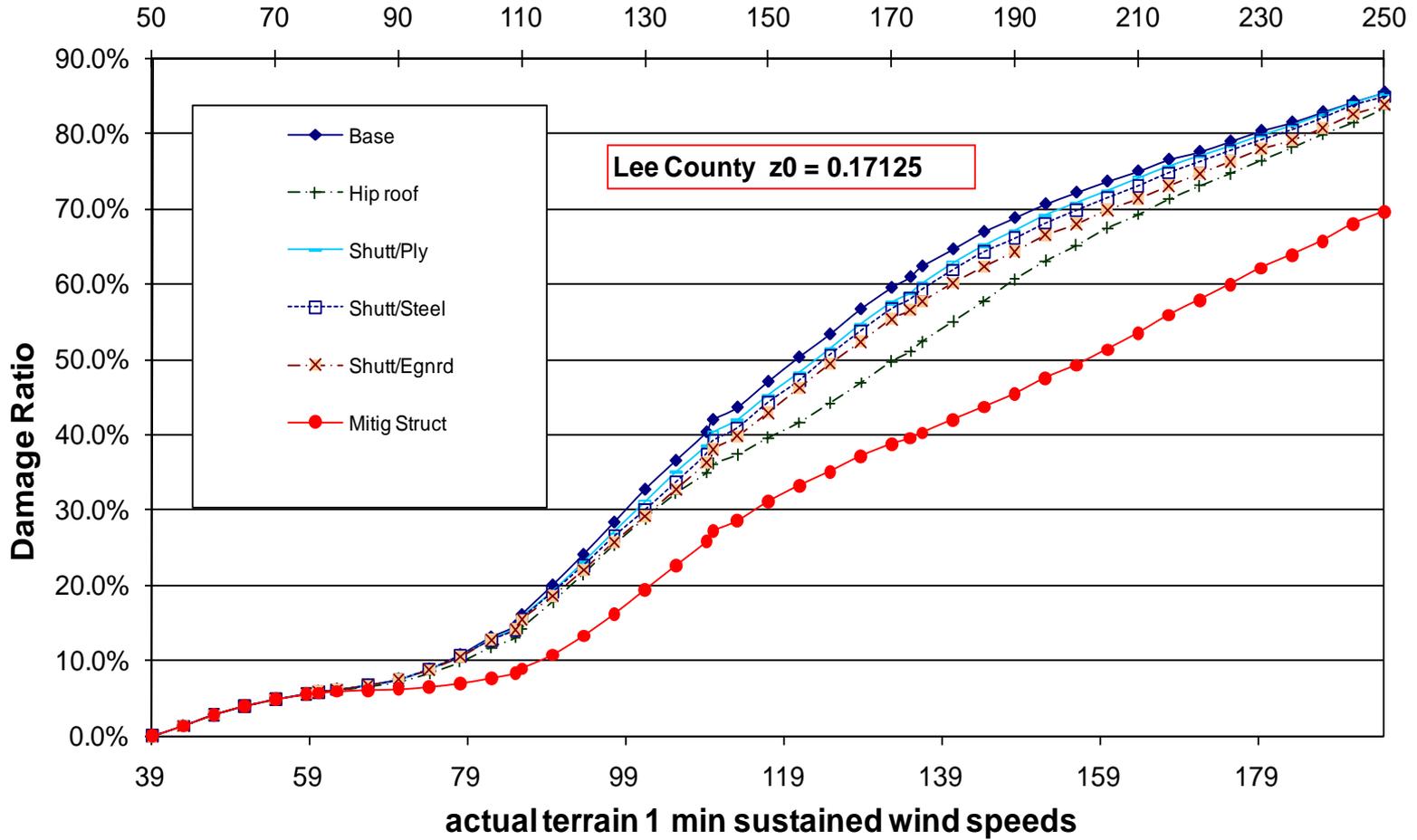
FL Keys have unique construction style.



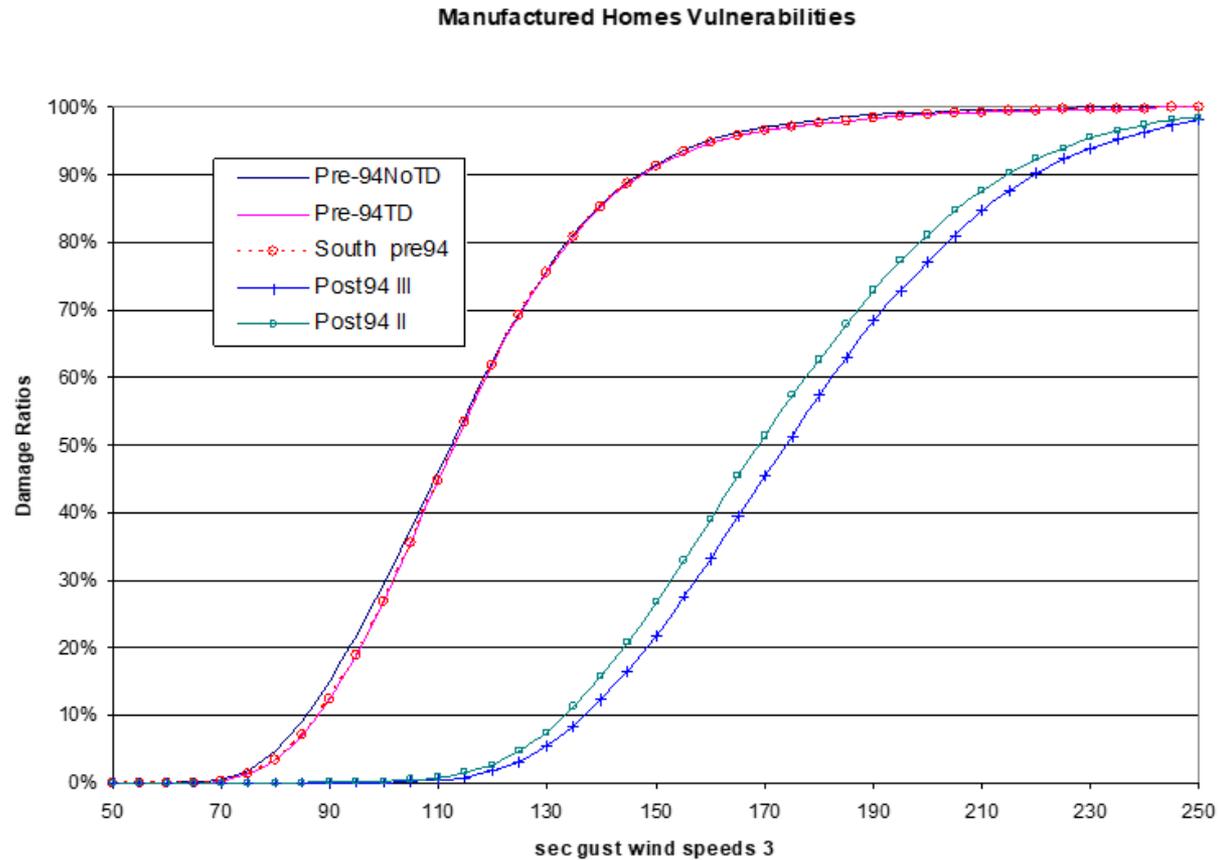
Weighted masonry structure vulnerabilities in the Central wind-borne debris region.

Vulnerability Curves for Reference Frame Structure - Mitigation set 3

actual terrain 3 sec gust wind speeds



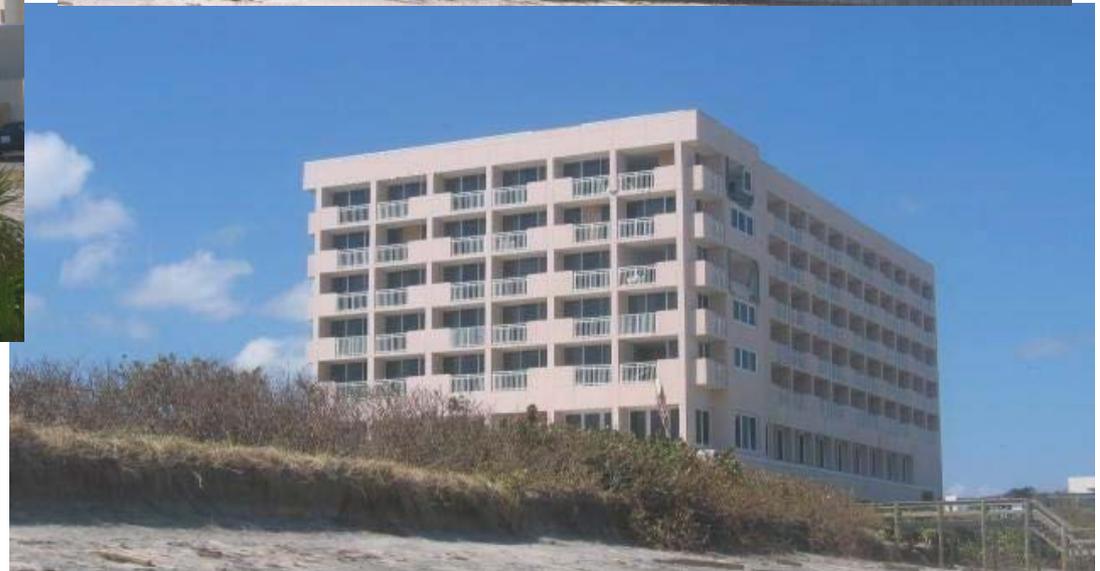
Manufactured Homes Vulnerabilities



FPHLM Wind speed vs height

- Winds at 100 m (around 28th floor) are 50% greater than at 10 m (3rd floor).
- If winds at surface are Cat 1, they will likely be Cat 3 on the 10th floor. Most of the increase in wind speed occurs at less than 60 meters (about 200 feet).
- If winds at surface are upper Cat 3, they will likely be Cat 5 on the 10th floor.
- High rise buildings are vulnerable to higher wind speeds and more rain water intrusion through breaches and openings
- The condo losses will increase exponentially with height
- We have a separate model for mid-high rise buildings

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



Mid-rise Modeling

- Mid-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**

Actuarial Loss Model Algorithms

- Two major algorithms have been developed
 - Probabilistic Insurance loss model (PILM)
 - Scenario Insurance Loss Model (SILM)
- In addition about 8 use cases/ algorithms were developed for estimating, for example, AAL, modeled losses for hypothetical storms, modeled loss costs for historical hurricanes, losses for different return time, PML, output ranges for modeled loss costs etc.
- Demand surge model generates loss amplification factors due to demand surge
- Loss adjustment expenses are not included in estimates of loss costs. The loss data used for validation do not include loss adjustment expenses.
- The modeled wind loss costs do not include storm surge losses.

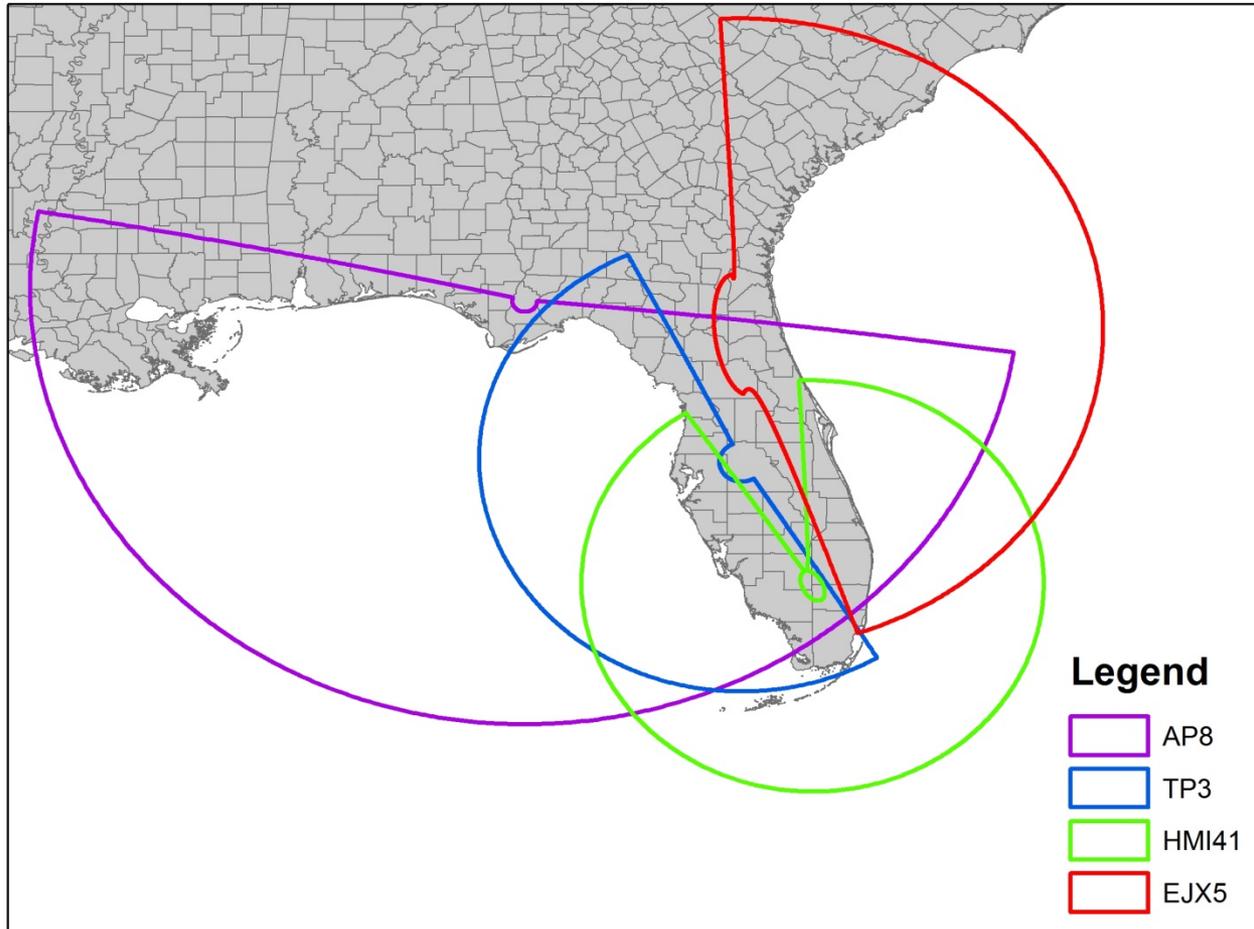
Storm Surge and Wave Models

Coastal and Estuarine Storm Tide (CEST) Model
ST Wave Model

Comparison of SLOSH and CEST

Items	SLOSH	CEST
Numerical method	Finite difference	Finite difference
Numerical scheme	Explicit	Semi-implicit
Grid format	Conformal grid	Orthogonal curvilinear
Bottom friction	Function of total water depth	Function of water depth and type of land cover
Overland flooding	Wetting and drying based on the relationship between water flows and water level elevations of neighboring cells	Wetting and drying based on accumulated water volume in a grid cell to conserve water volume
Wind field	SLOSH Wind	SLOSH , Holland wind, WRF, H*Wind
Time step for synthetic cases	3-15 seconds	15-60 seconds
Tides and waves	No tides and waves	Coupled
Computation time	3-30 minutes	3-20minutes

4 Surge model Domains for Florida



- 1. AP8 Basin**
Apalachicola Bay
- 2. TP3 Basin** **Tampa Bay**
- 3. HMI41 Basin** **South Florida**
- 4. EJX5 Basin**
Florida Atlantic

Systematic Integrated CEST Model

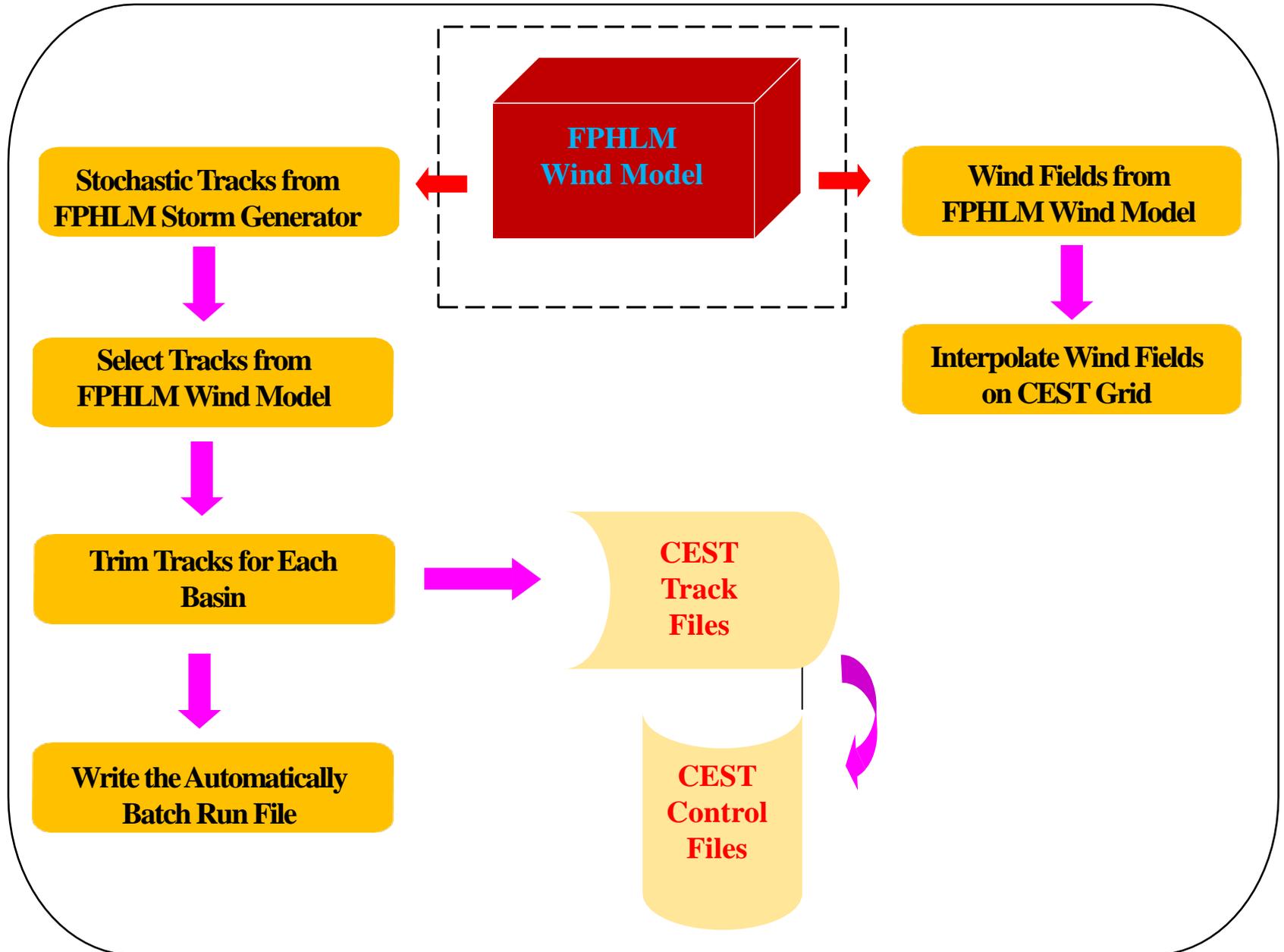
Preprocessor

- Elect and trim the stochastic storm tracks generated from FPHLM Wind Model
- Generate NETCDF grid file from basin shape file
- Automatically create the corresponding tracks and control files required by CEST automatically write the batch run file

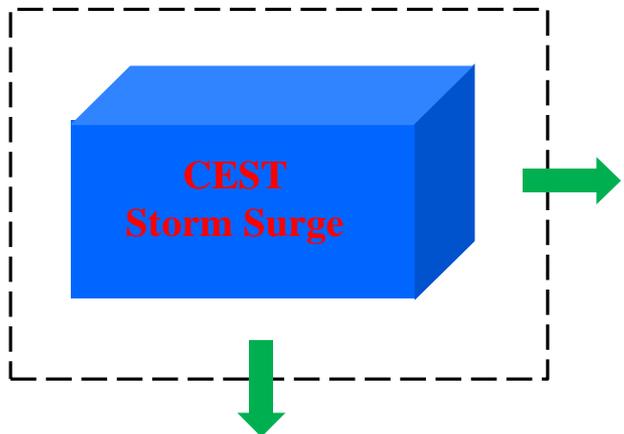
Postprocessor

- Output the variables required by wave and engineering teams
- Display the maximum surge
- Extract the Envelop of Maximum Surge
- Interpolate surge in specified location

Preprocess of CEST



Postprocess of CEST



Produce Outputs for Engineer Team

1. Maximum Surge
2. Maximum Surge Related Wind Speed
3. Maximum Wind Speed
4. Maximum Wind Speed Related Surge
5. Water Elevation Time Series
6. Wind Speed Time Series

Produce Outputs for Wave Team

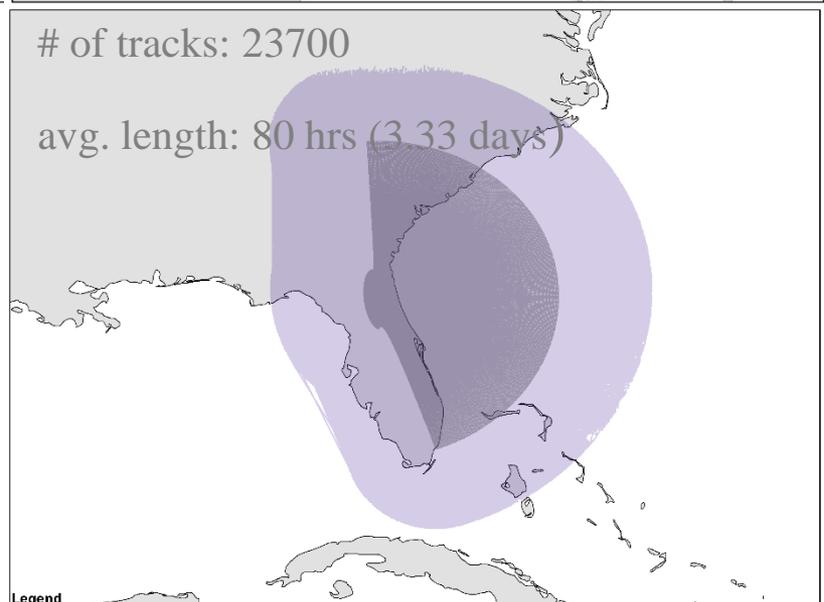
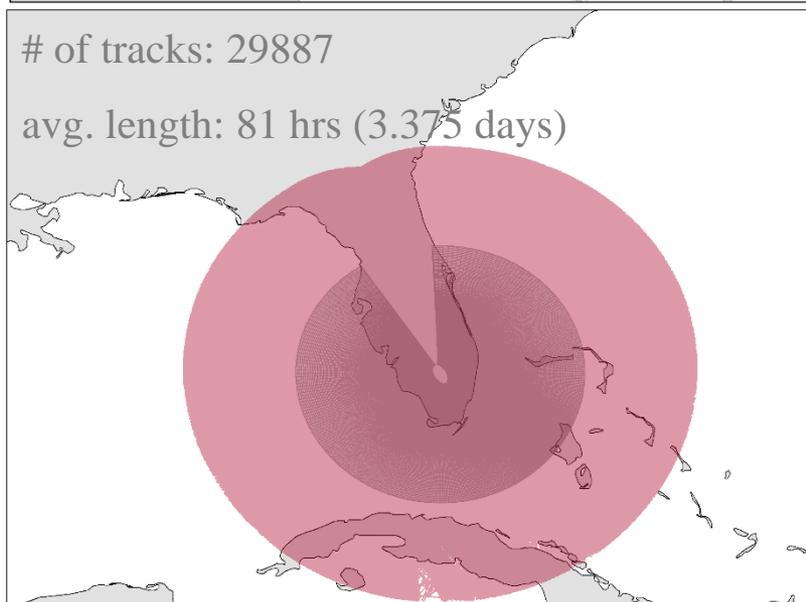
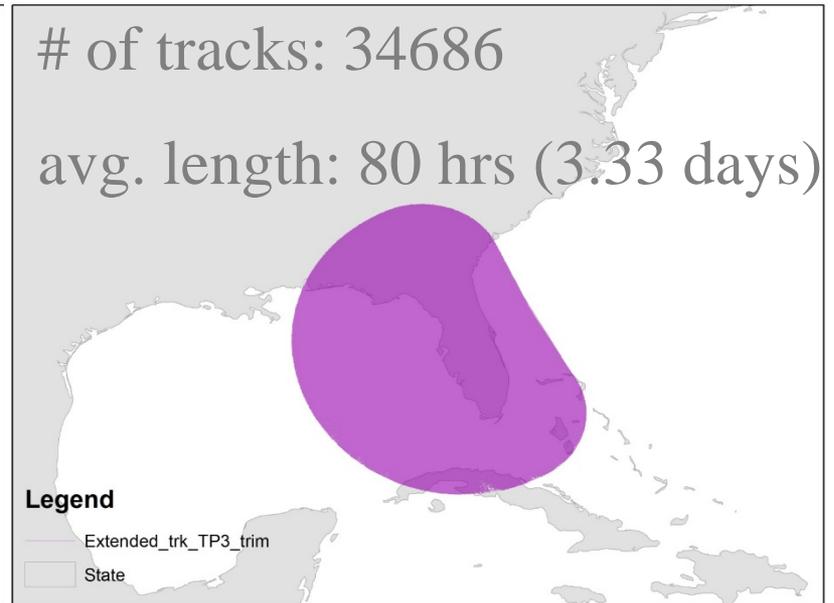
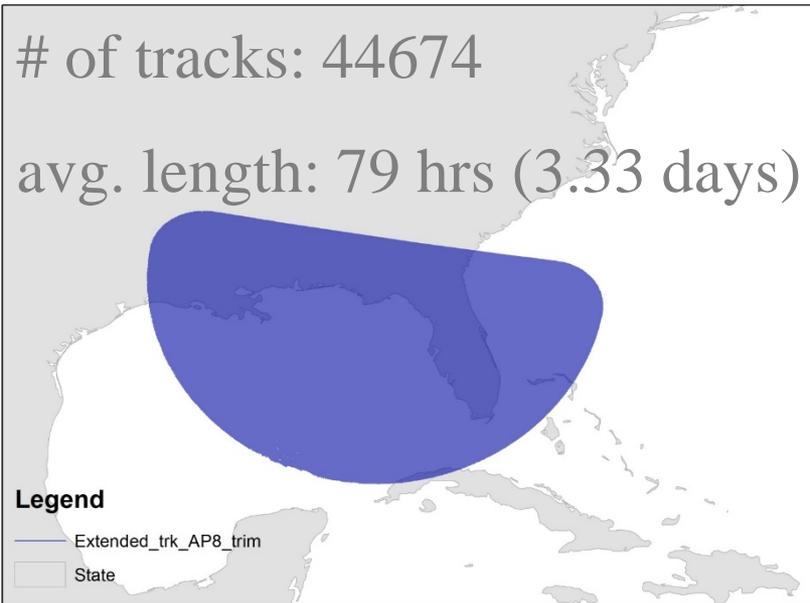
1. Maximum Surge
2. Depth
3. Maximum Wind Speed

Display the Maximum
Surge

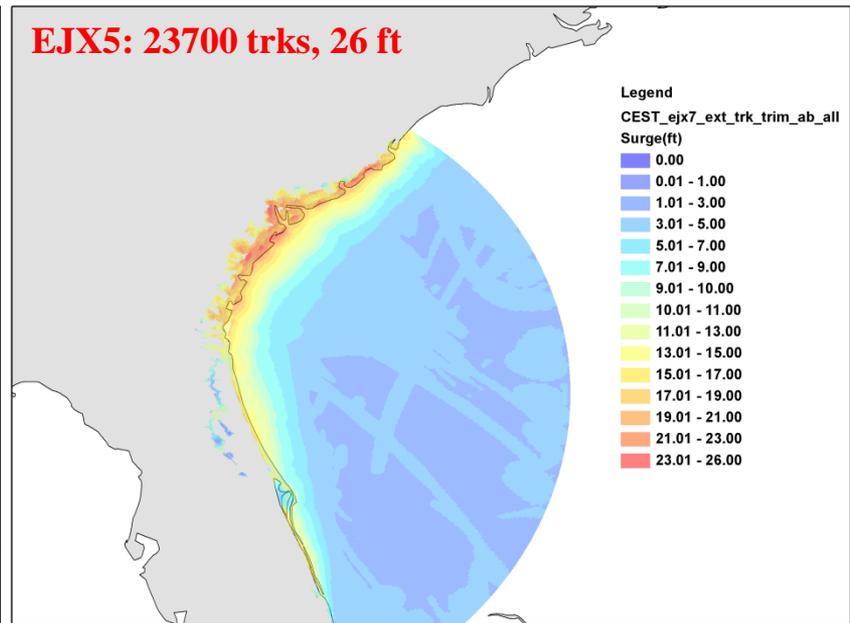
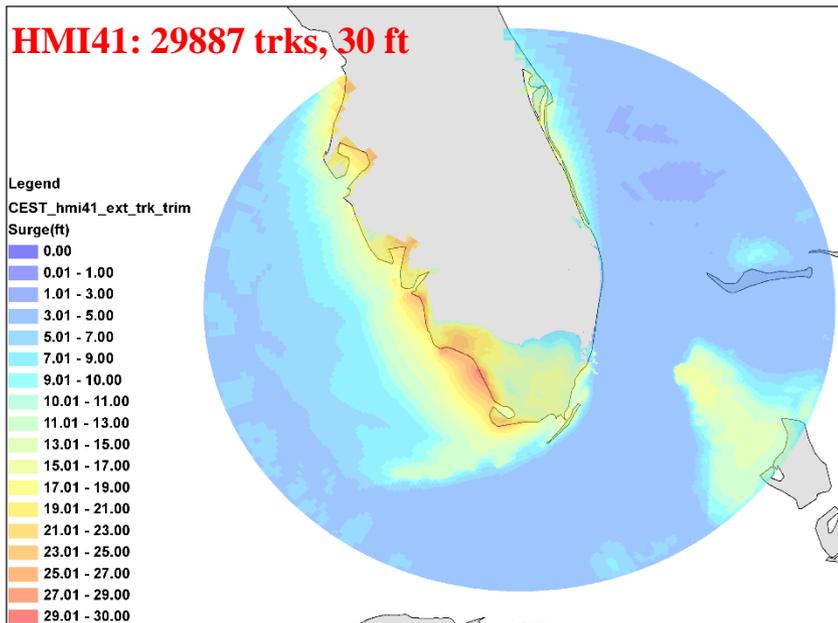
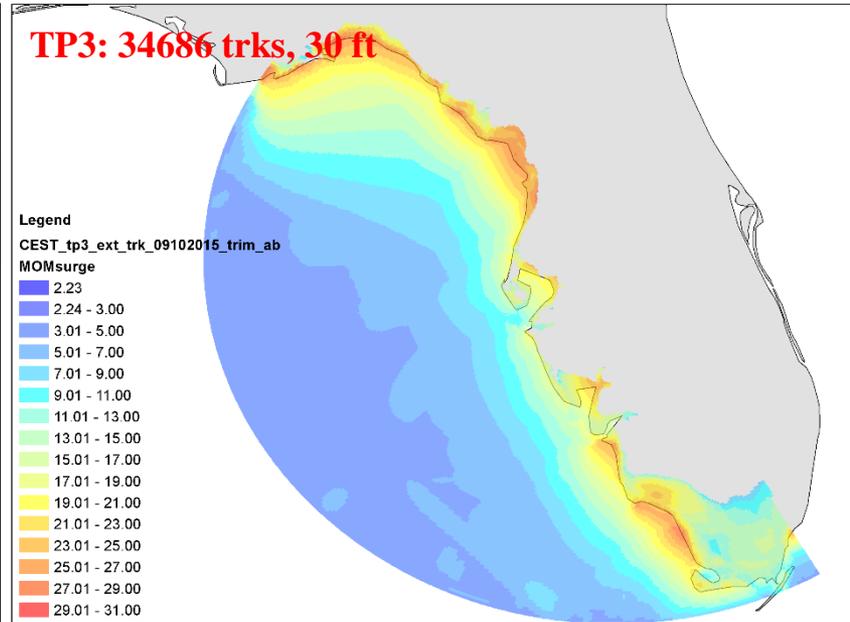
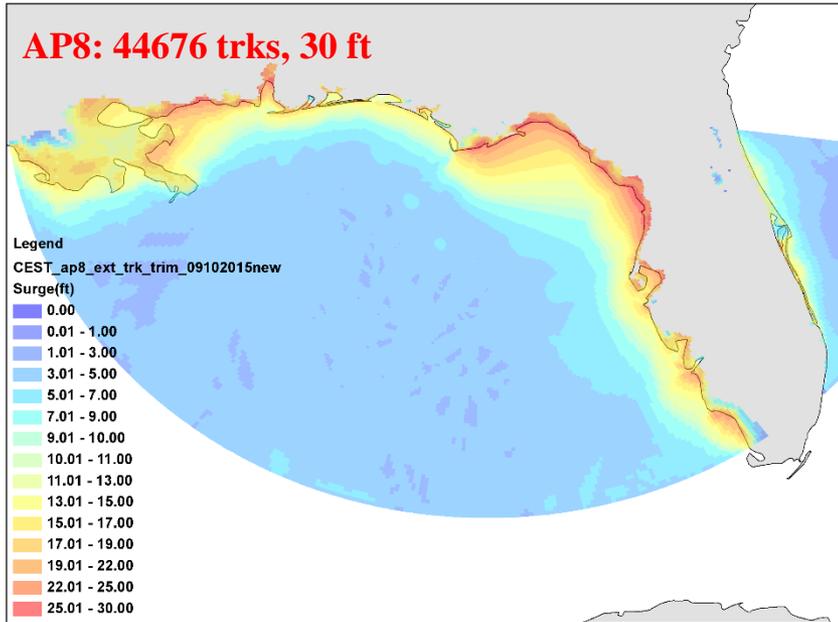
Extract the Envelop of
Maximum Surge

Interpolate Surge in
Specified Location

Stochastic Track Set for 4 Basins



Maximum Surges for 4 Basins



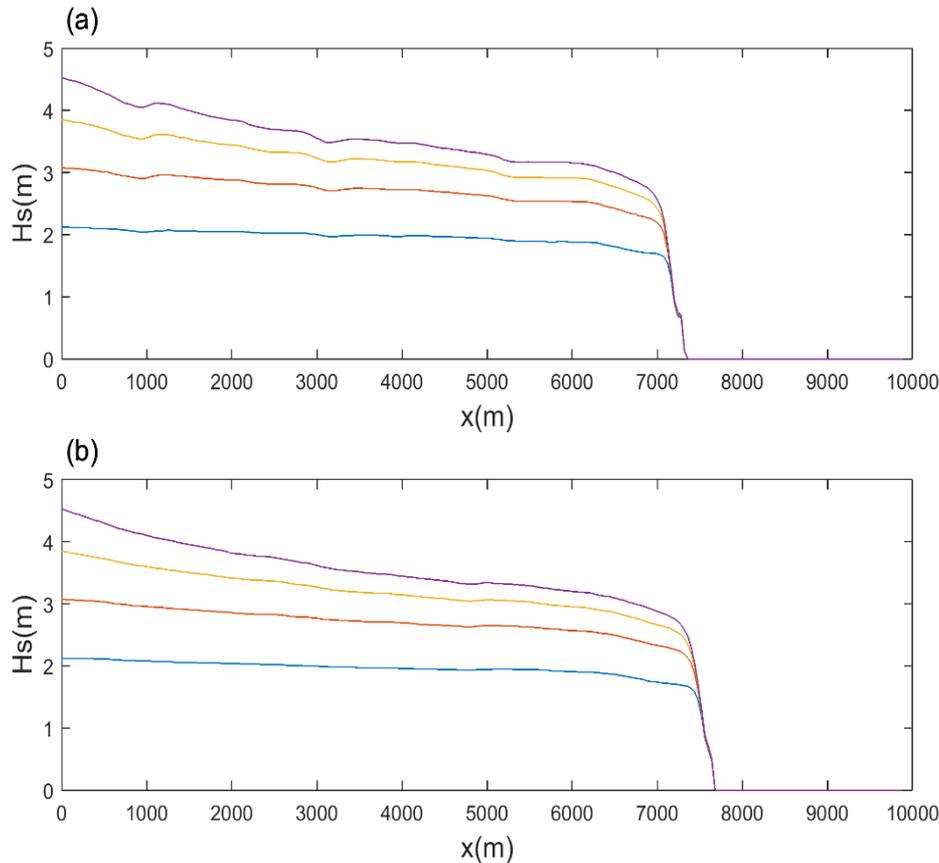
Wave Effects

- Waves riding on surge cause significant damage to structures on normally dry land
- FPHLM computes significant wave heights over land for the entire ~78k member stochastic storm set over the Florida Peninsula
 - 40m grid size
 - 116 subgrids
 - Uses slightly modified version of STWAVE
 - Uses 300 parallel processes to finish stochastic set in around 3 weeks
 - Each storm run twice: at time of max surge, and time of max wind
- Local wave heights become an input into damage and loss models

Assumptions

- STWAVE steady wave model developed by US Army Corps of Engineers and used in many coastal flooding studies
 - Grids start several km offshore
 - Thornton and Guza irregular wave breaking dissipation added
 - Frictional dissipation based on land use/land cover types
 - Coastal wave height and period inputs based on parametric hindcast using wind speed and fetch
 - One frequency/many directions for efficiency
 - Initial surge elevations from surge output
 - No wave setup applied

Wave Height Dependency on Wind Speed



- Need an offshore boundary condition for wind model
- Uses Young and Verhagen (1996) methodology
- Inputs of wind speed, fetch and depth
- For open fetches, Kennedy et al (2010) showed that this works fairly well
- Overland wave heights are actually not so sensitive to initial wave heights
- More sensitive to surge levels

Wave height variation with wind

Inland Flood Model

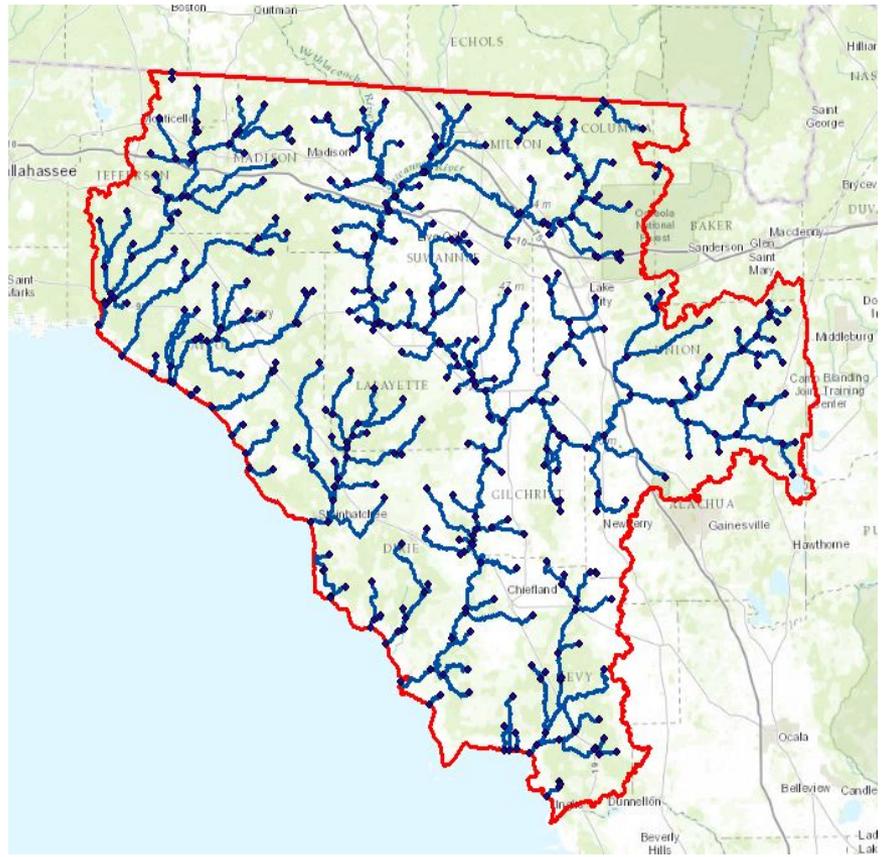
- Developed and maintain six EPA SWMM models to predict stormwater (rainfall-led freshwater) flooding over Florida.
- Calibrated (train) and validate (test) the models.
- Developed and maintain a separate EPA SWMM model for the wetlands, isolated islands, and keys.
- Used the models to simulate stormwater led overland flooding under the historical hurricanes and storms at claim locations.
- Predicted stormwater based overland flooding depths due to 50K/60K extreme storm events.

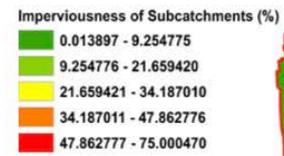
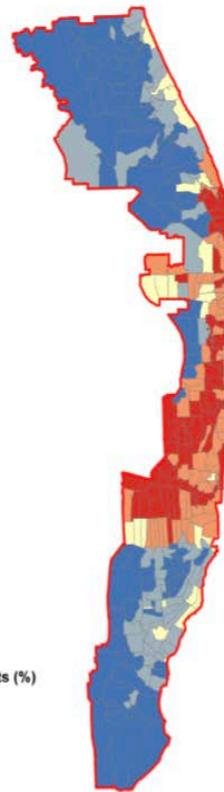
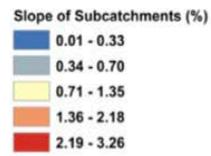
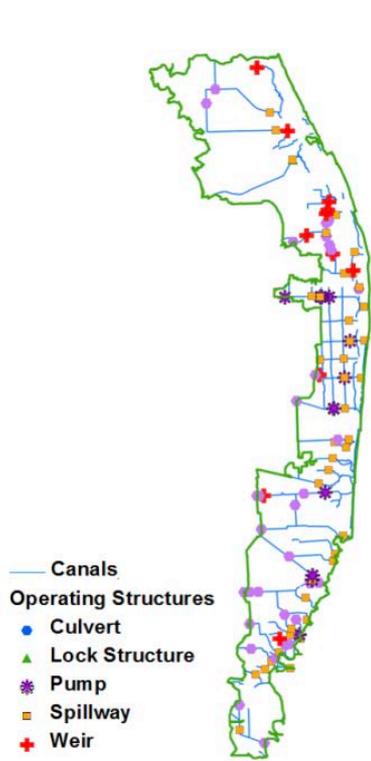
Study Basins



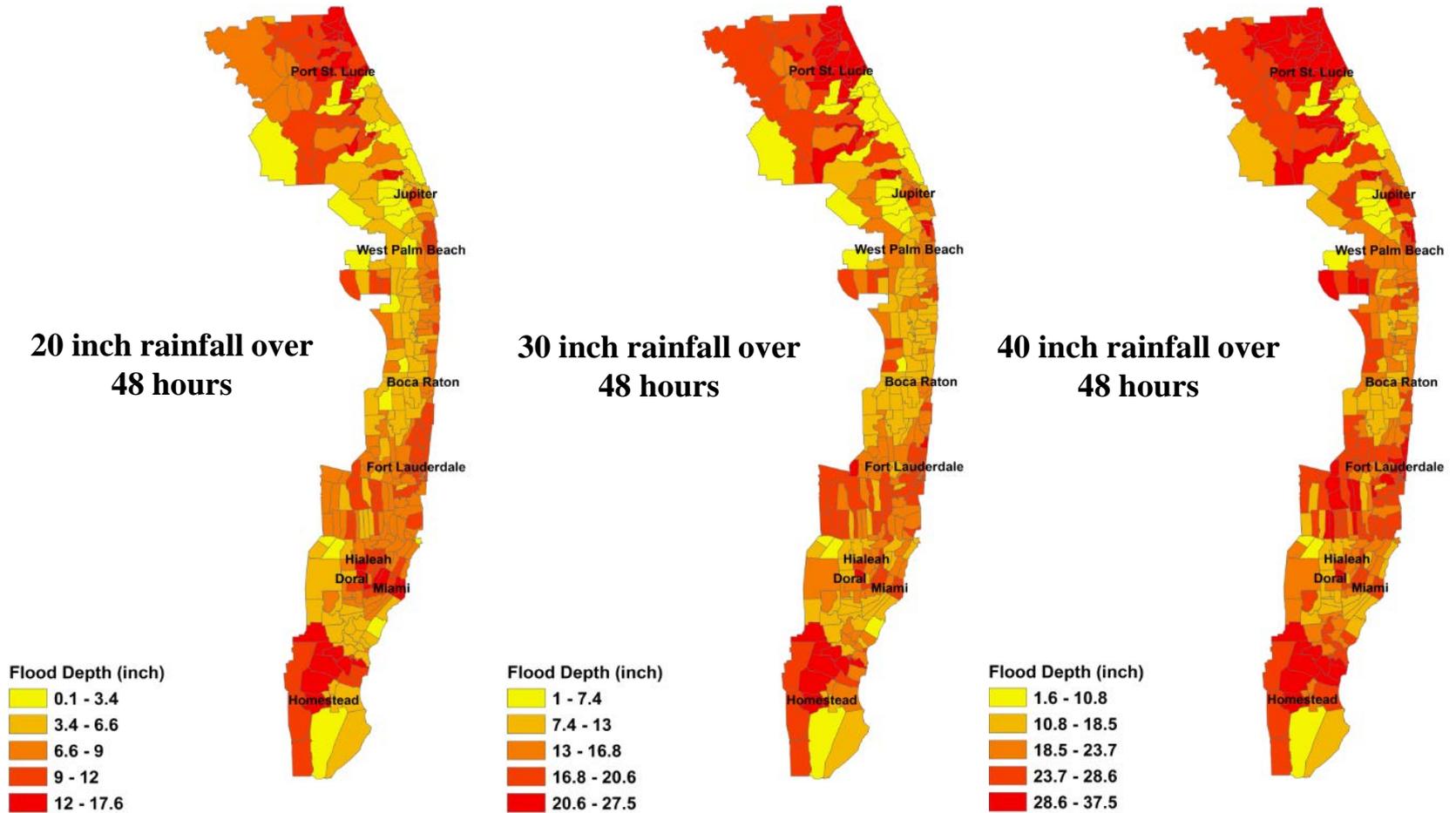
Methodology

- Each Study basin has been divided into different subbasins, and drainage network is established based on Digital Elevation Model (DEM).
- Land cover parameters such as % slope, % imperviousness, roughness coefficient, and hydrological variables such as rainfall, groundwater level, evapotranspiration were incorporated into the model.
- The developed model is calibrated and validated against historical streamflow/water level to ensure accuracy (minimum bias) and efficiency (high coefficient of determination, R^2).
- The calibrated and validated model are used to obtain inland flooding depths at subbasin levels for 50K/60K storm events.
- In order to obtain flood elevations at policy locations within the six basins, we interpolate the subbasin level flooding elevations to the claim locations by adopting inverse distance weighing approach with four nearest neighboring points.





Inland Flood Modeling Output



SE Subbasin Level Flooding Depths under Different Rainfall Scenarios

Engineering vulnerability model for surge and flood

- We combine two methods to develop surge vulnerability curves from the literature available for tsunami fragility curves

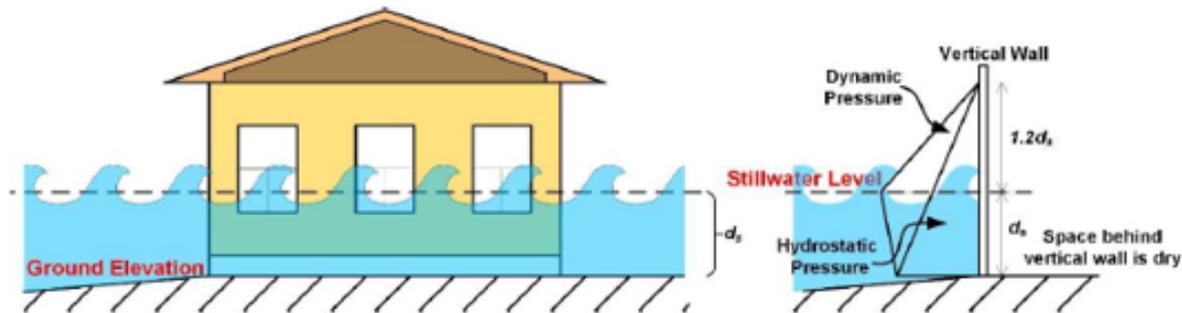
Hydrological forces

Tsunami forces:

$$F_{tsunami}/l = 4.5\gamma_w d_s^2$$

Storm surge forces:

$$F_{surge}/l = C_p \gamma_w \frac{H_{des}}{0.78} \left(\frac{d_s + 2 \times 0.7 H_{des}}{2} \right) + \frac{1}{2} \gamma_w (d_s + 2 \times 0.7 H_{des})^2$$



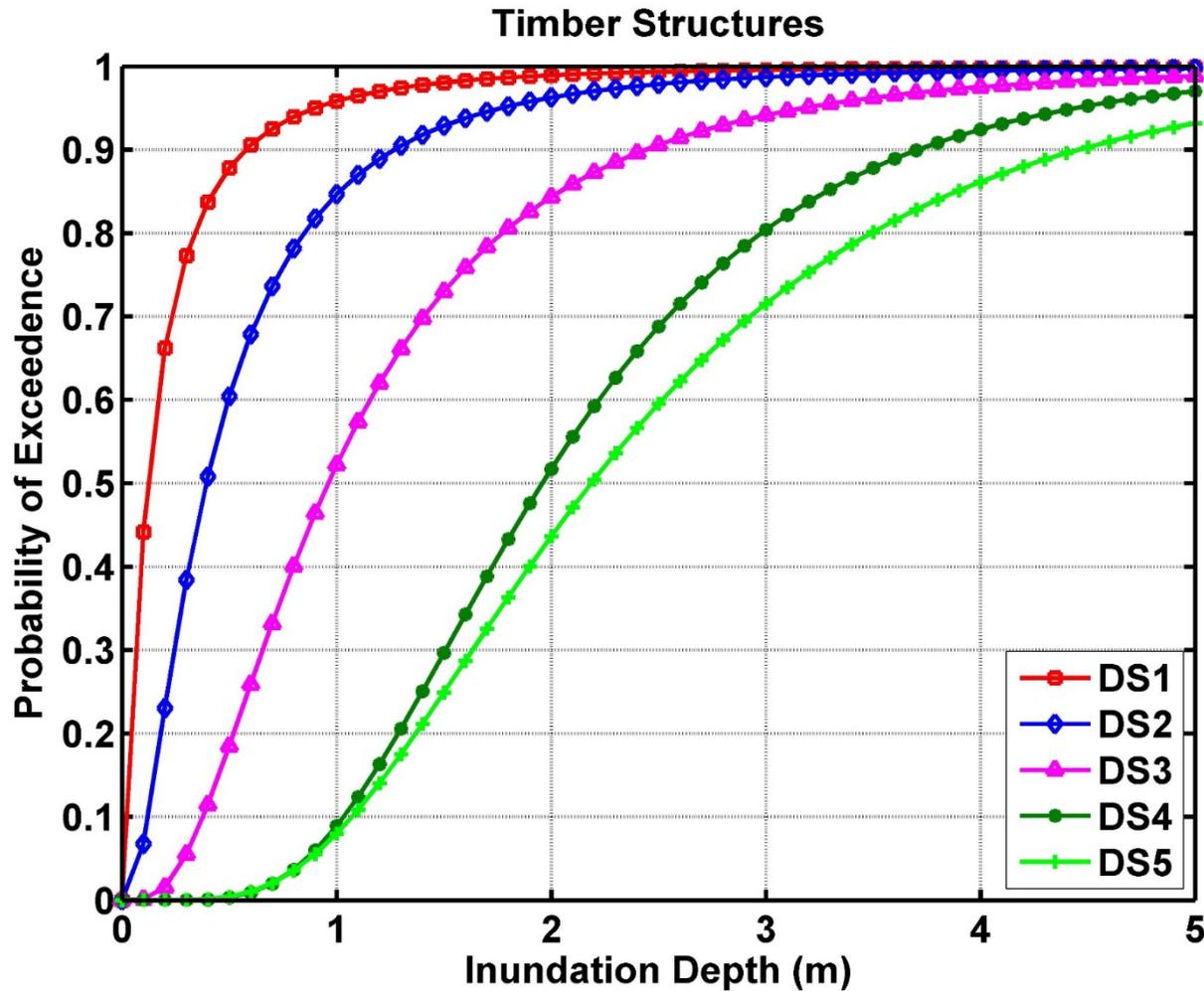
Surge Damage States

Component	Surge Damage States					
	DS 1	DS 2	DS 3	DS 4	DS 5	DS 6
Roof	No visible damage	Few roof covering missing or damaged (<15% of roof area) Roof covering damage only	Significant amount of roof covering missing (15-50%) Few roof sheathing damage (<15%)	The majority of roof covering missing Many roof sheathing damage (15-40%) Few roof trusses damage (<15%)	Extensive roof trusses damaged Severe damage to interior content due to water intrusion	Entire roof missing
Exterior Walls	No visible damage	Minor wall siding removal (<10% of 1 wall) Small scratches Cracks in breakaway wall	Wall siding has been removed from >10% of 1 wall or from multiple walls Few wall sheathing damage (<10%) Cracks in many walls Breakaways walls damaged or removed	Extensive damage to wall siding (50% of walls) Partial loss of wall sheathing caused by water or debris Large and extensive cracks in most wall Few wall frame damage	Large holes due to <u>floodborne</u> debris Extensive loss of wall sheathing Reparable wall frame damage	Overall wall system has collapsed
Interiors	No visible damage	Infiltration damage to floor covering & items below first floor Light damage to plumbing, mechanical and electric systems Minor water damage to utility and cabinets	Water marks 0 to 2 <u>ft</u> above first floor Significant interior damage, including plumbing and electrical systems Dampness on >20% of dry wall (Mold)	Water marks 2 to 4 <u>ft</u> above first floor Water damage to interiors at high level Interior stairway damaged or removed Dampness on >50% of dry wall (Mold)	Water marks 4 to 6 <u>ft</u> above first floor Interior damage >60%	Interior damage > 80%
Foundation	No visible damage	Slightly scour Evidence of weathering on piles	Slab and piles experience extensive scour without apparent building damage	Slab and piles sustain significant scour with repairable structural damage Moderate slab crack	Structure shifted off the foundation or overturning foundation Piles: racking Slab: undermining leads to significant deformation	Buildings collapse
Openings	No visible damage	1 window or door is broken (glass only) Screens may be damaged or missing	>1 window and ≤ the larger of 20% and 3 Damage to frames of doors and windows	> the larger of 20% & 3 and ≤ 50%	> 50%	Damage >80%

Outputs:

- The output library currently includes results for:
 - Single family on Grade (SFG) for timber and masonry structures, for 1, 2 and 3 stories.
 - Single family Elevated (SFE) for timber and masonry structures, for 1 and 2 stories.
 - Mobile Homes (MH) Tied-down and Not Tied-Down.
 - Low-rise commercial residential (LRCR), same as SFG.
 - Mid high-rise commercial residential (MHCR) for reinforced concrete and reinforced masonry, for each level from 1 to 3.

Tsunami Fragility Curves for One-Story Timber Structure (Suppasri et al. 2013)



Computational infrastructure

55 servers

1304 CPU cores

Selected output from the wind loss model

Average Annual Loss

Based on 2017 Cat Fund exposure data

Personal and Commercial Residential

- Zero deductible statewide AAL = \$4.7 billion
- Net of deductible statewide AAL = \$3 billion

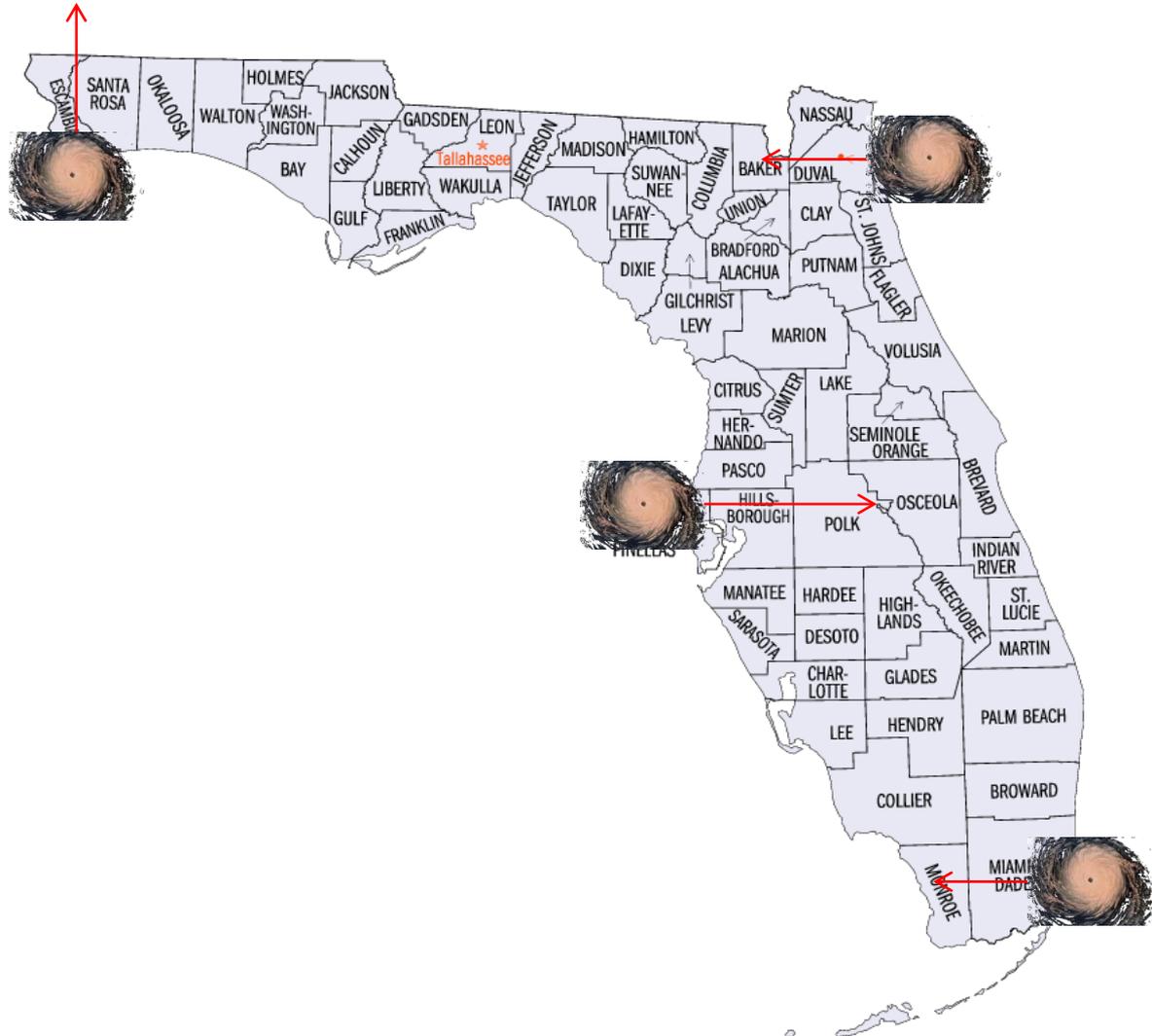
Personal and Commercial Residential PML (zero deductible)

Return Period (Years)	Estimated Loss Level (Billions)
500	\$71
250	\$63
100	\$51
50	\$42
20	\$28
10	\$18
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.

Simulated events: Identical Cat 1, 2, 3, 4, 5 hurricanes landing at 4 key locations in Florida, Jacksonville, Miami, Tampa, and Panama City



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

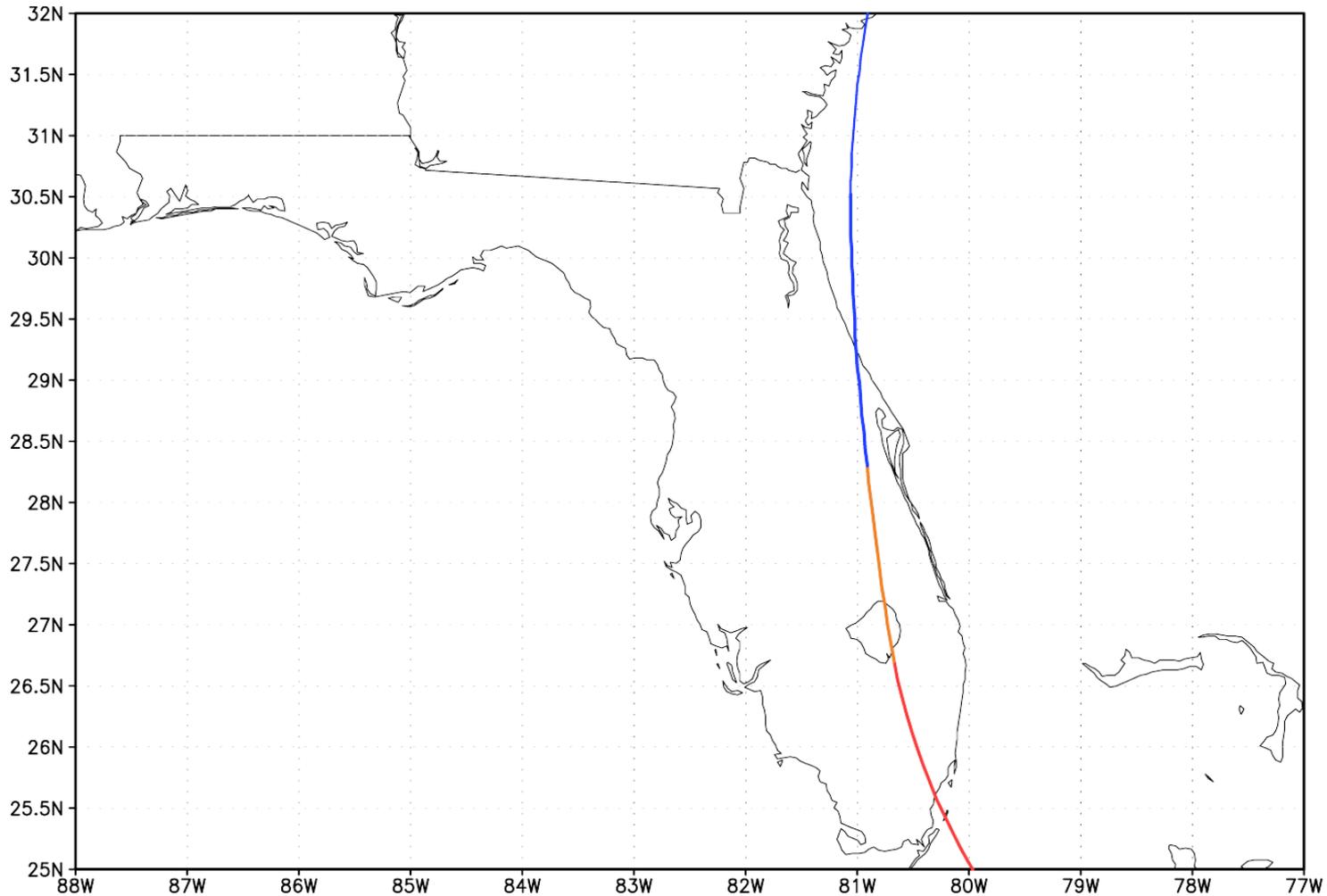
- As expected, Tampa and Miami produce the highest personal residential losses and are the most vulnerable areas.
- Highest net of deductible losses are \$43.6 billion produced by a Cat 5 hurricane landing in Tampa and going east (goes through the highly populated suburbs of Orlando)
- Current deductibles significantly reduce the amount of insurance payouts
 - Deductibles 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

Current Insured Losses from Historical Storm

- For current Florida personal and commercial residential policies only

Andrew	\$18 billion
Sept 1926 hurricane	\$40.6 billion
1928 Okeechobee	\$44.4 billion
Donna	\$20 billion
Wilma	\$17.6 billion

Worst Case Scenario: Track of a very large, very intense cat 5 hurricane Gross Insured Loss of \$147 billion



Maximum Damage Reduction (%) Due to Mitigation Measures

	Masonry	Frame
• Roof strength		
• BRACED GABLE ENDS	1%	1%
• HIP ROOF	7%	11%
• Roof Covering		
• RATED SHINGLES (110 MPH)	1%	1%
• 8d NAILS	38%	37%
• Wall-Floor Strength		
• STRAPS	---	10%
• Roof to Wall Strength		
• CLIPS	12%	14%
• STRAPS	15%	23%

Maximum Damage Reduction (%) Due to Mitigation Measures

	Masonry	Frame
• Wall-Foundation Strength		
• VERTICAL REINFORCING	22%	---
• Opening Protection		
• PLYWOOD	7%	6%
• STEEL	12%	10%
• ENGINEERED	15%	13%
• Window etc Strength		
• LAMINATED GLASS	12%	11%
• IMPACT GLASS	14%	13%
• Total Mitigated Structure	40%	41%

- These estimates may be revised after FIU WOW (wind tunnel) tests

Mitigation Discounts

Homeowner annual insurance premium for \$300,000 masonry home in Miami (2017)

1992 built home (unmitigated)	\$13,500
1992 built home (mitigated)	\$6,500
2005 built home (new code)	\$5,000

Hurricane Irma Wind Loss Estimate

- Gross loss = \$19.3 billion
- Insurers pay \$6.4 billion

Statistical Validation

- **Wind loss model:**
- Modeled vs Actual losses from 66 hurricane/company portfolios of policies.
- The comparison indicates a reasonable agreement between the actual and modeled losses. The correlation between actual and modeled losses is found to be 0.97
- Paired t-test and other tests also show there is no significant difference between the actual and modeled losses
- **Surge and flood loss model:** calibration and validation ongoing

Lesson from past hurricane

- The part of the house most vulnerable to hurricane wind is the roof and roof to wall connection.
- Much improvement in building codes and roof design and connection but still very vulnerable to major hurricane.
- Wood roof are not suitable for hurricane prone area. Need to switch to concrete roof.
- Engineers at FIU have patented 1.5 inch thick lightweight but strong concrete roof with waves that can stand up to 200 mph wind. Cheap to build and install.

Potential Extensions

- Economic loss model including business loss model
- Models for other vulnerable Atlantic states