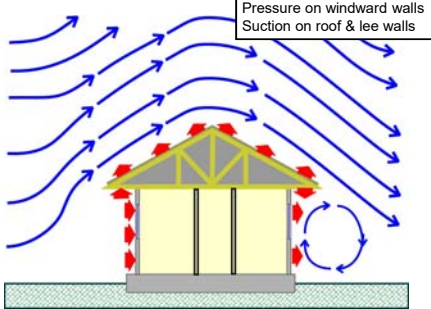




How Do Buildings Fail in a Hurricane?

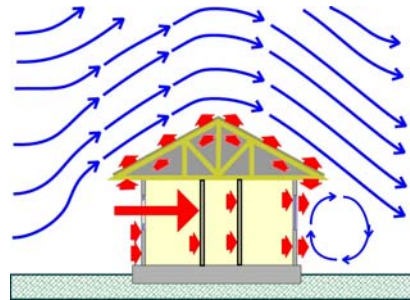


Wind Flowing Around a House



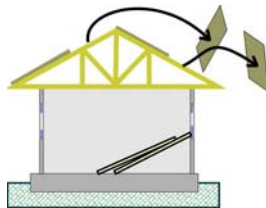
Flying debris causes failure in addition to the dynamic pressure of the wind.

Breaching the Building Envelope Adds Internal Pressure to External Suction



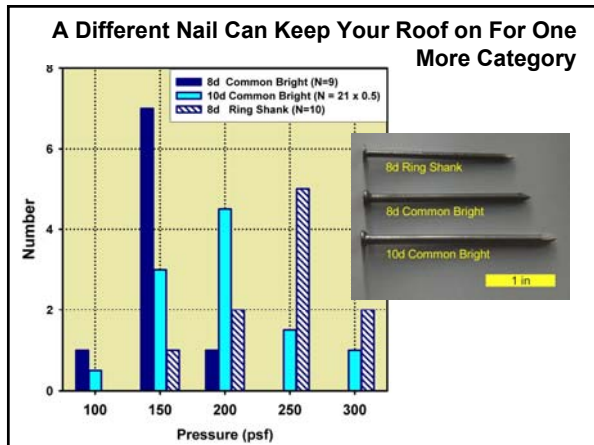
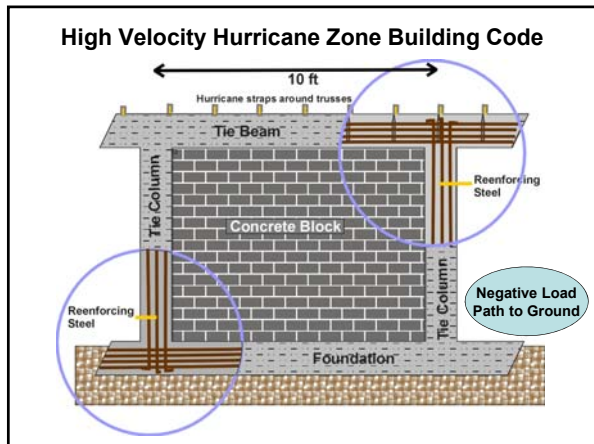
Structural Failure(s)

- Shingles or roof tiles fail
- Rainwater enters
- Windows, entryway doors & garage doors
- Soffits blow upward
- Interior walls collapse
- Roof sheathing blows off
- More rainwater enters



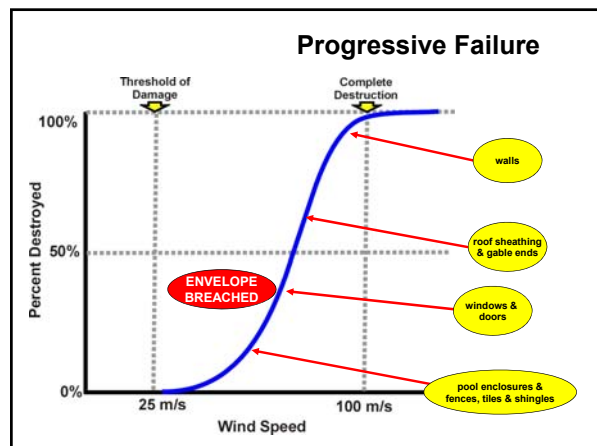
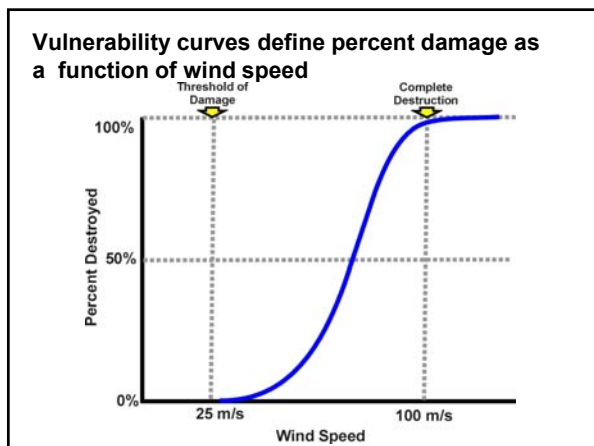
Shutters





Failures "Prevented" by High Velocity Hurricane Zone Building Code

- Failure of doors & windows
- Collapse of interior walls
- Roof detachment from walls
- Toppling of unreinforced exterior masonry walls
- "Prevented" really means failure moves to higher wind speed



Where the Vulnerability Curve Starts to Ramp Up



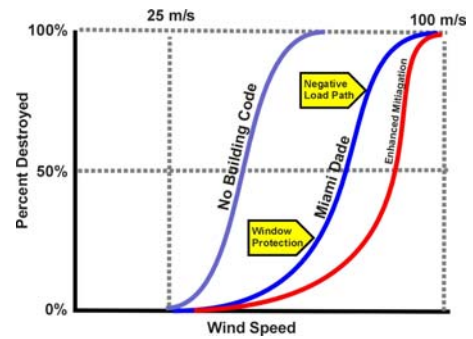
Farther Up the Curve



Devastation



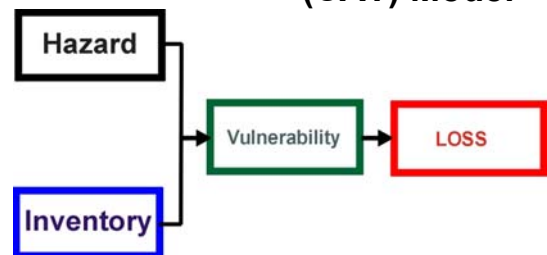
Schematic Effect of Construction Standards on Vulnerability



How Do Insurance Companies Set Rates?

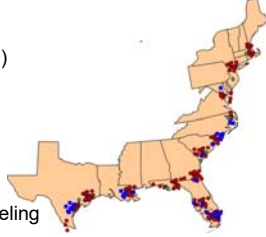
- Inventory of insured structures (**Book of Business**)
- Climatology of hurricanes
- Vulnerability curves for various kinds of construction
- Costs of claims based upon damage and terms of policies
- Regulation by state and federal governments

Structure of a Catastrophe (CAT) Model

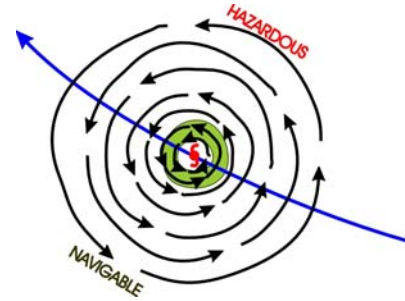


Inventory Module

- Digital list of insured structures
- Information
 - Location (zip or Lat/Lon)
 - Insured value
 - Type of construction
 - Size
 - Number of stories
 - Year built
 - History--losses, remodeling
 - Coverage



Hazard Modules are Based Upon the Redfield-Reid Paradigm

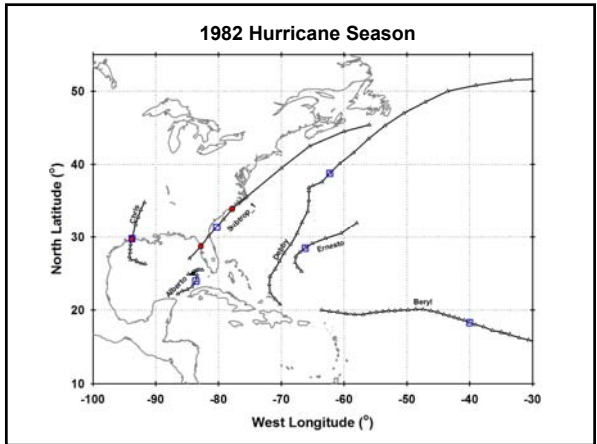
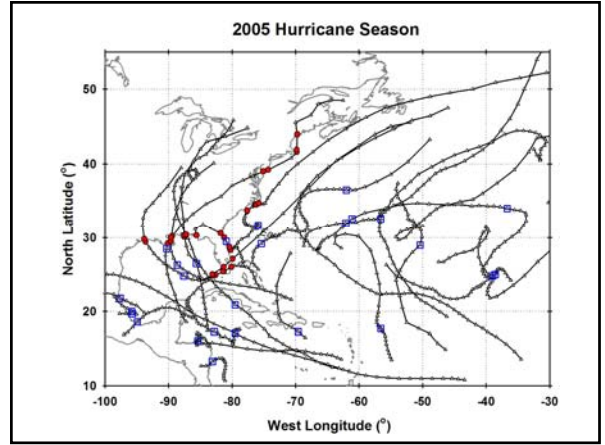


Statistics From HURDAT File

- Record of Atlantic TCs back to 1851
- Not complete before 1900 (or maybe 1944)
- Tabulates Lat, Lon, Pmin, Vmax, landfall every 6 hours
- Developed for forecast verification
- Has taken on the status of a legal document

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64450 0804200000 0 0 0000000 0 0 0000000 0 0 1200335 25 100P
64460 0804200000 0 0 0000000 0 0 0000000 0 0 1200335 25 100P
64470 0804200000 0 0 0000000 0 0 0000000 0 0 1200335 25 100P
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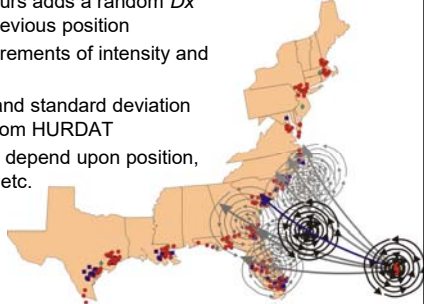
Synthetic Hurricane Seasons

- Generate ~1000 virtual hurricane seasons
- Go through each season day-by-day
- For each 10° (or 5°) square generate (or not) a random starting intensity and motion
- Generate history of track, intensity & size
- Combine the cyclones and repeat for another virtual season



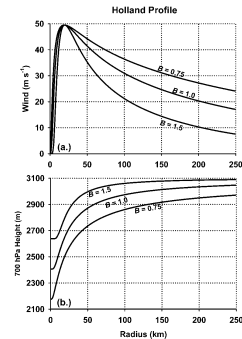
Model Track and Intensity Using a Markov Process

- Every six hours adds a random Dx and Dy to previous position
- Also add increments of intensity and size
- With mean and standard deviation calculated from HURDAT
- Probabilities depend upon position, day of year, etc.

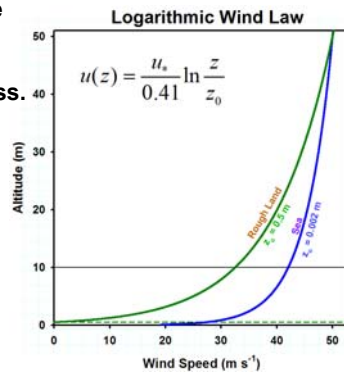


Many CAT Models Use the “Holland” Parametric Wind Profile

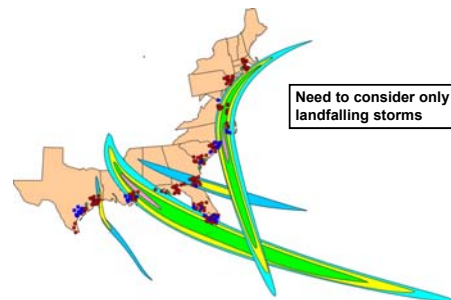
- Parameters are
 - Minimum Pressure,
 - Radius of Maximum Wind
 - B, the “Width Parameter”
- Monte-Carlo model of changes
- Generate winds for each virtual hurricane



Vertical structure of the wind depends upon surface roughness.



Virtual Storms Impact on Actual Insured Property

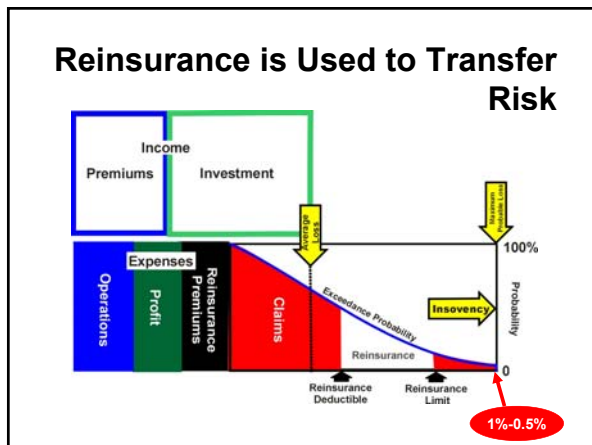
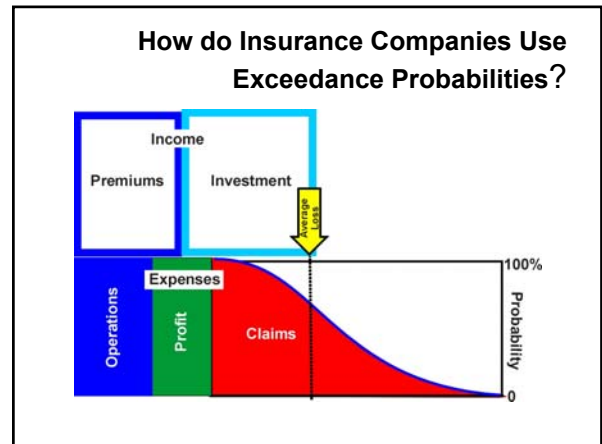
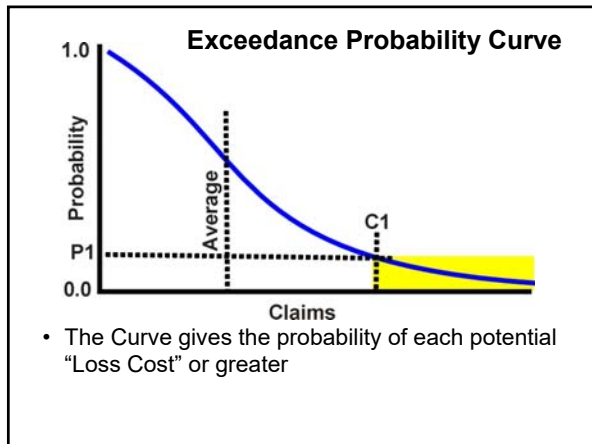


Cost Module

- Converts damage to repair/replacement costs---i.e. to claims
- Depends upon
 - Kind and extent of damage
 - Cost of labor and materials
 - Post-storm demand surge
- Generally includes
 - Structure contents
 - Temporary accommodations

CAT Model Summary

- Generate many (~1000) random hurricane seasons with the same climatology as HURDAT
- Calculate damage and claims for the company’s Book of Business
- Count from most damaging to least damaging and sort from least damaging to most damaging
- Divide count by number of seasons and tabulate as a function of predicted claims to get **Exceedance Probability** curve



- ### Summary
- Damage caused by
 - Dynamic Pressure
 - Flying Debris
 - Water penetration
 - Failure of building envelope progresses to structural failure
 - Mitigation
 - Negative load path
 - Protection of windows and doors
 - Vulnerability Curves: Percent damage as a function of wind speed
 - Catastrophe model modules
 - Hazard: Hurricane number, intensity, size ...
 - Vulnerability: Amount of insured property in harm's way
 - Loss: Models failure of structure
 - Cost: Combines damage and policy terms to estimate claims
 - Exceedance Probability: Probability of a given Loss Cost or more
 - Reinsurance: Insurance for insurers--covers loss above some (large) deductible and below policy limit
 - Maximum Probable Loss
 - 1% or 0.5% on XP curve
 - Larger losses may cause insolvency