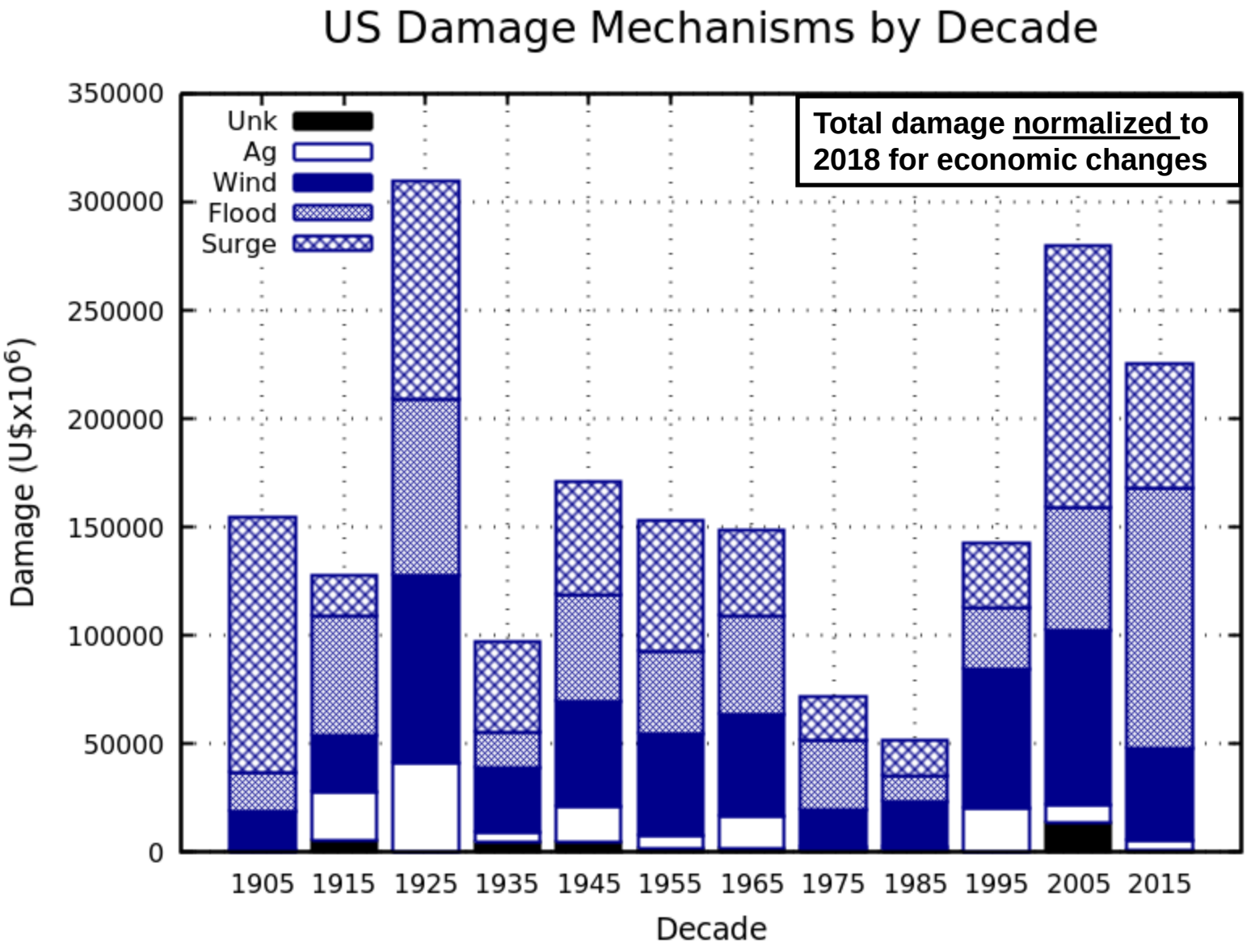
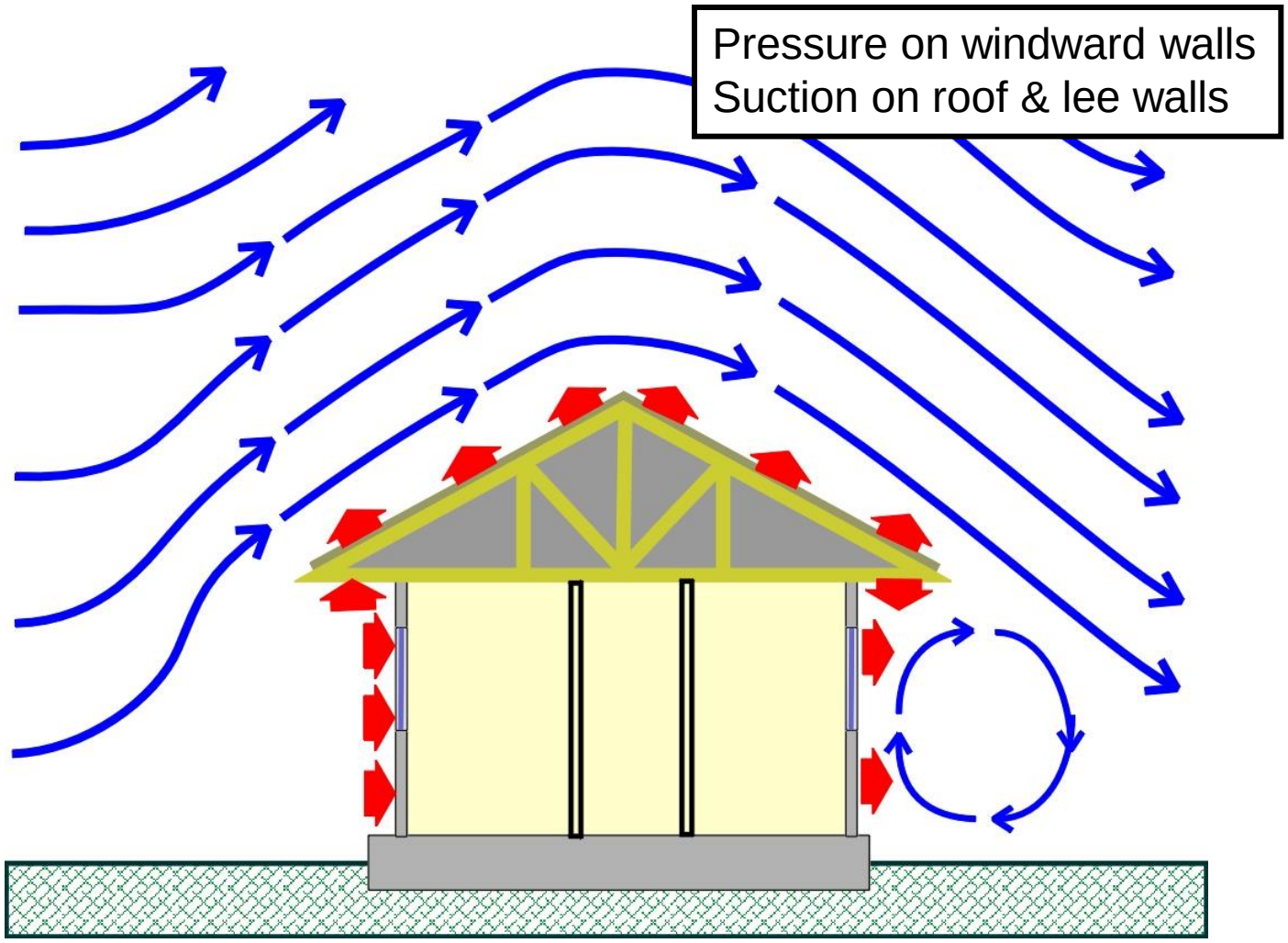
2019 RA-IV Workshop

Societal Aspects of Hurricanes
Wind Storm Insurance
Hugh Willoughby, FIU
9 May 2019

How Do Buildings Fail in a Hurricane?

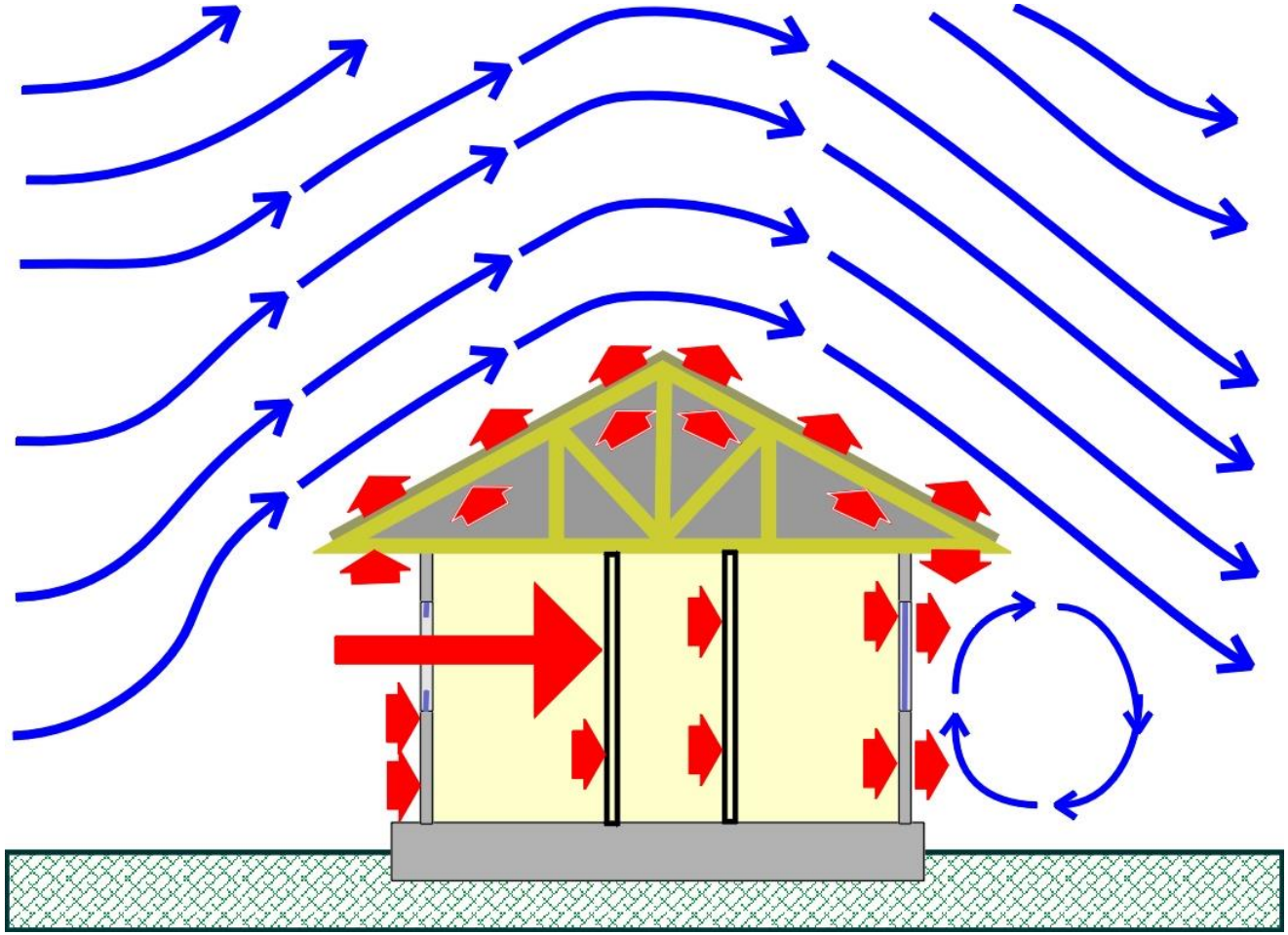

US Damage Mechanisms by Decade
Total damage normalized to 2018 for economic changes
Unk
Ag
Wind
Flood
Surge
Damage (U$x10⁶)
350000
300000
250000
200000
150000
100000
50000
0
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
2015
Decade

Wind Flowing Over a House



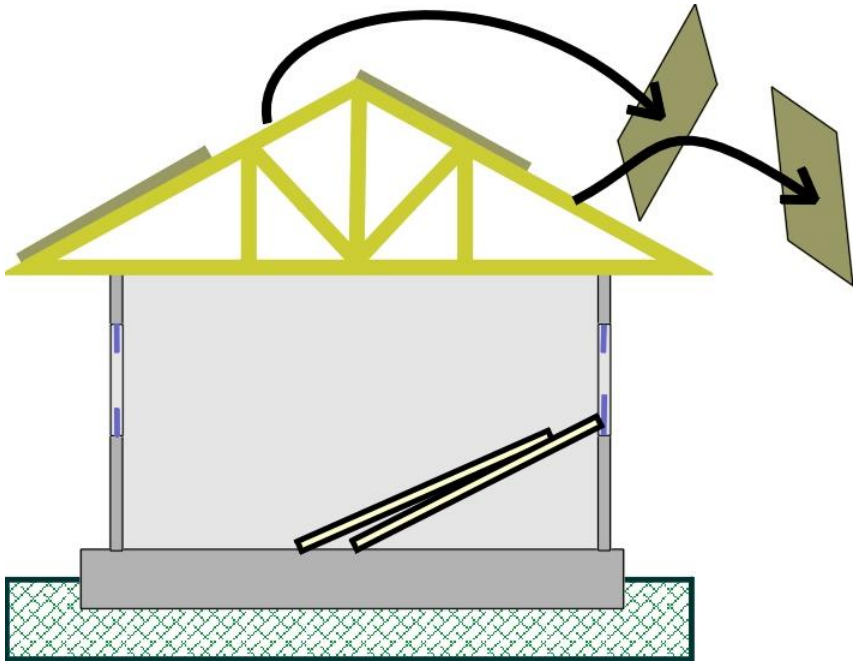
Flying debris causes failure in addition to the dynamic pressure of the wind.

Breaching the Building Envelope Adds Internal Pressure to External Suction



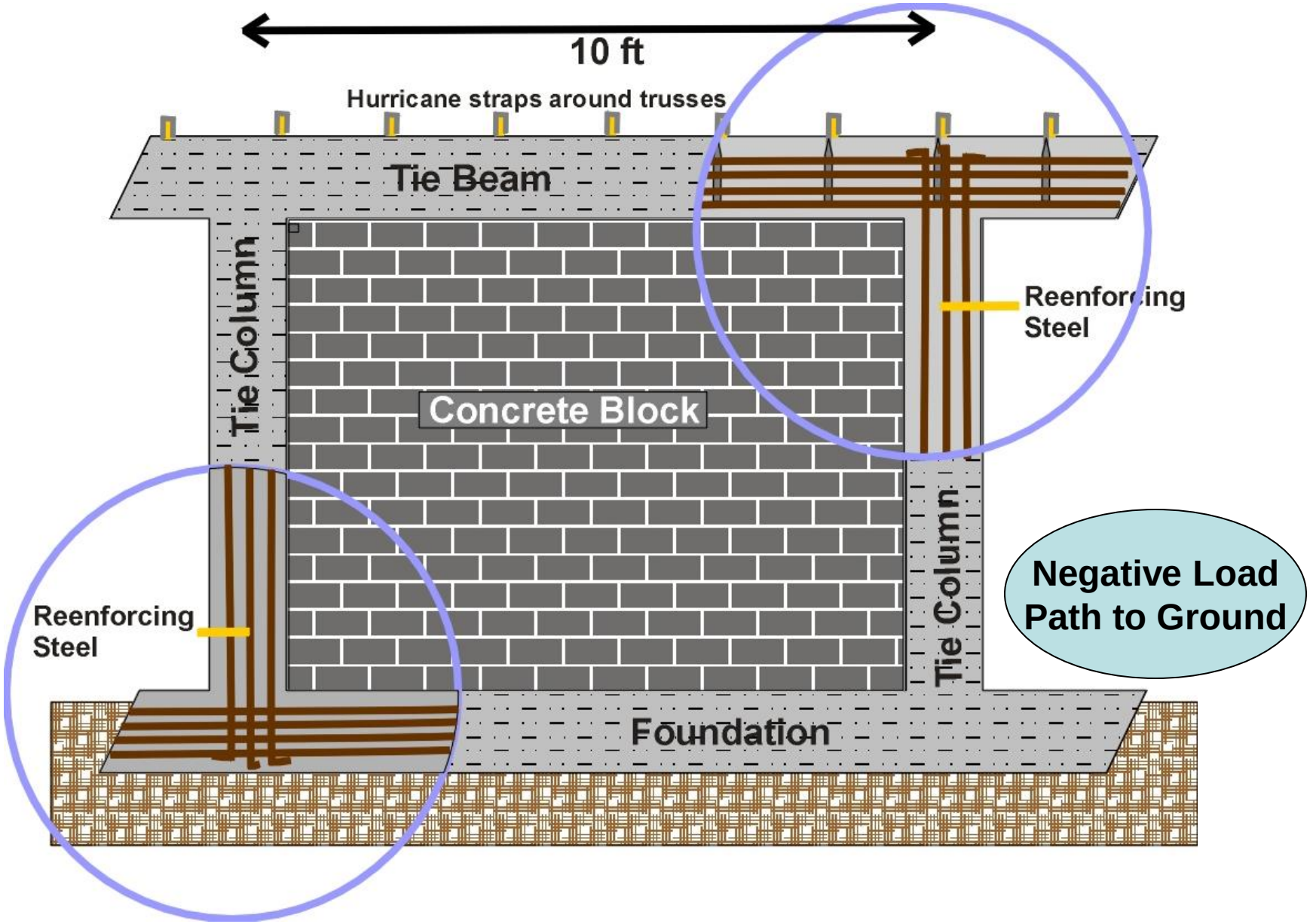
Structural Failure(s)

- Shingles or roof tiles fail
- Rainwater enters
- Windows, entryway doors & garage doors fail3
- Soffits blow upward
- Interior walls collapse
- Roof sheathing blows off
- More rainwater enters



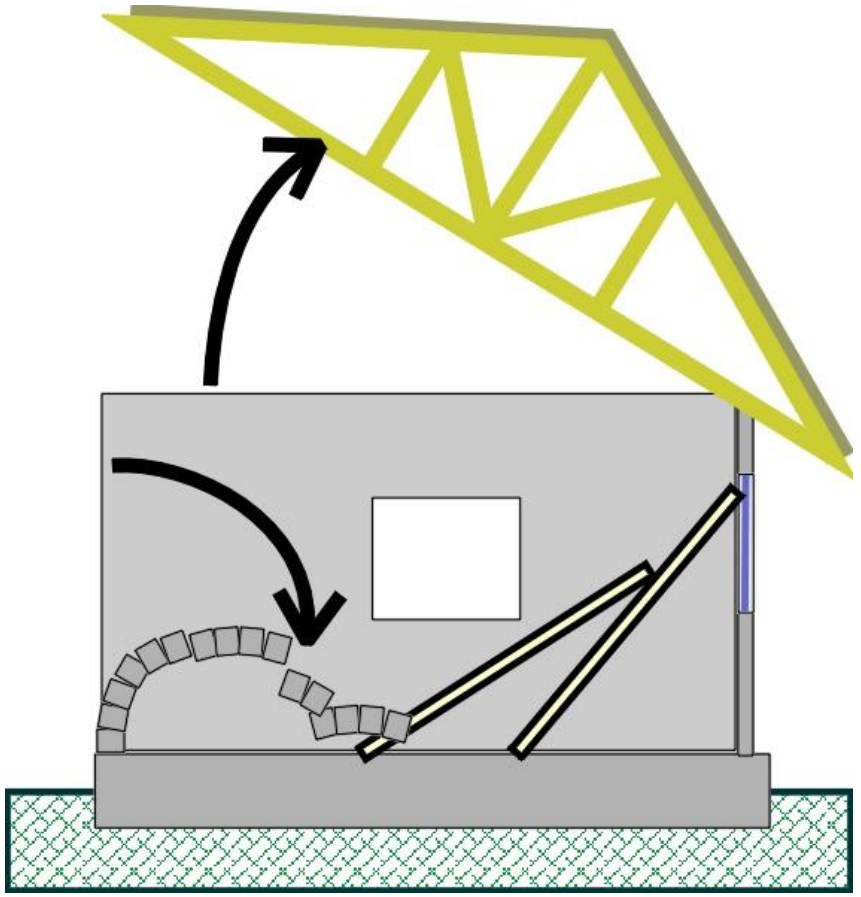
Shutters

High Velocity Hurricane Zone Building Code

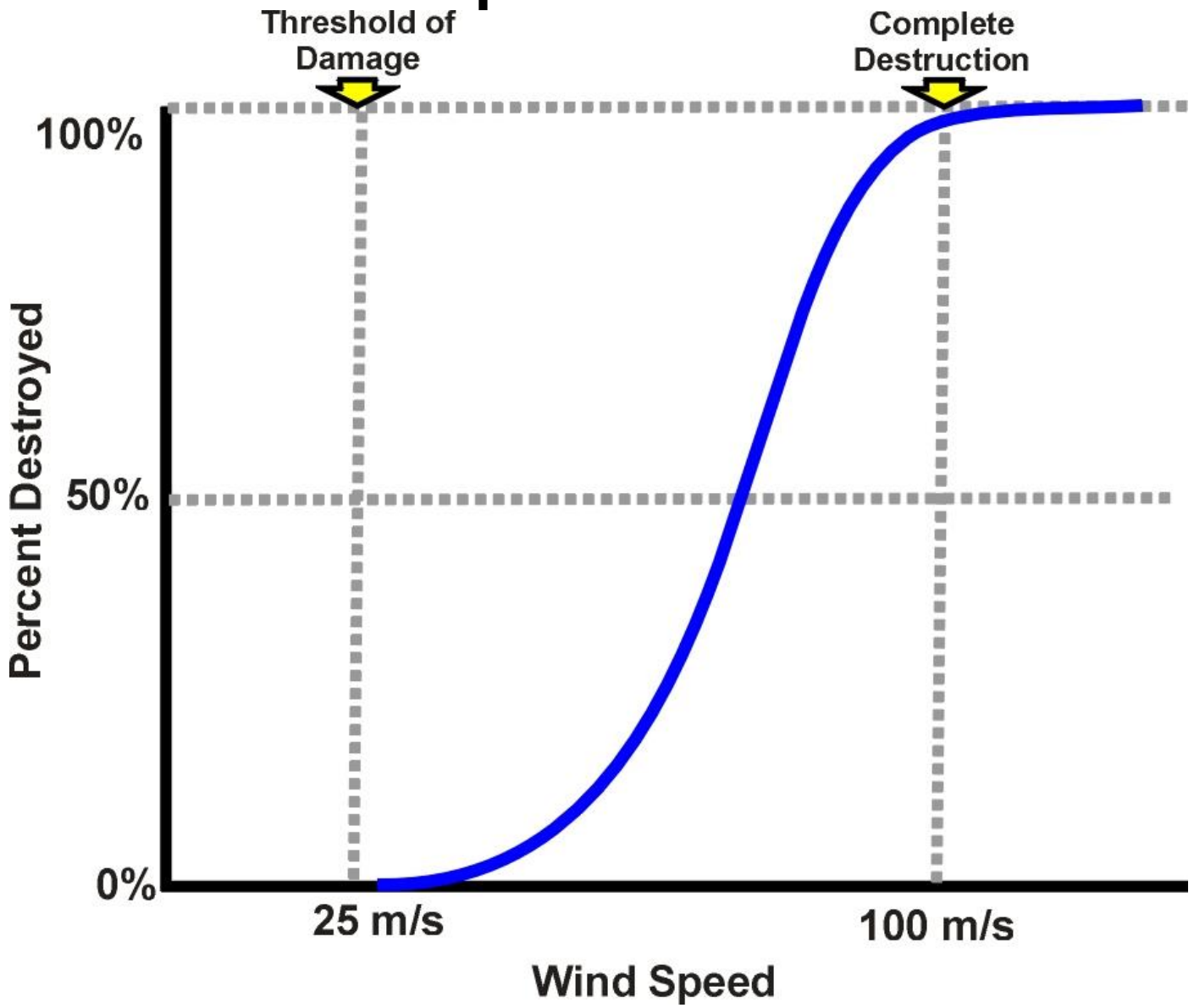


Failures “Prevented” by High Velocity Hurricane Zone Building Code

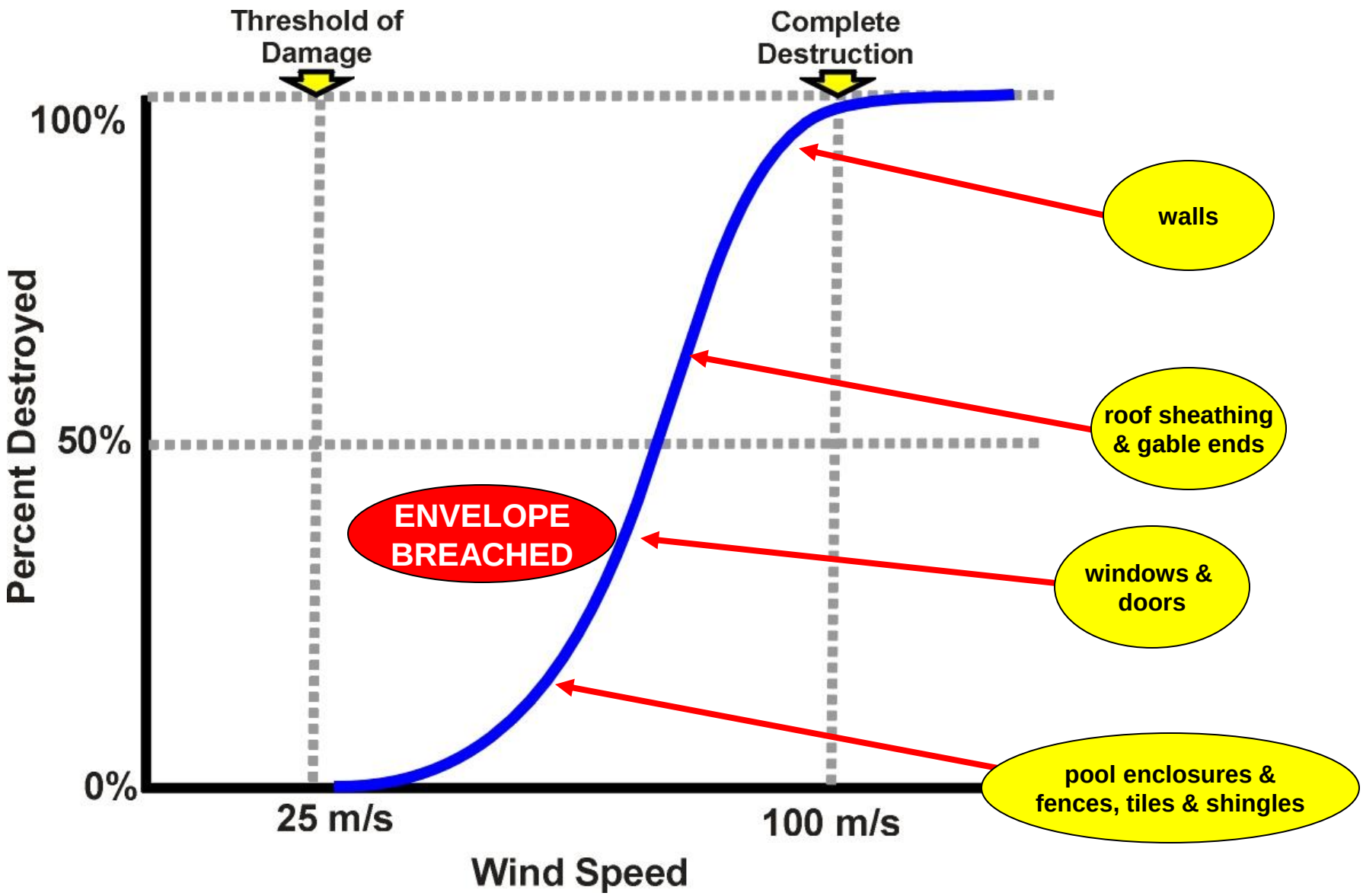
- Failure of doors & windows
- Collapse of interior walls
- Roof detachment from walls
- Toppling of un-reinforced exterior masonry walls
- “Prevented” really means failure moves to higher wind speed



Vulnerability curves define percent damage as a function of wind speed



Progressive Failure

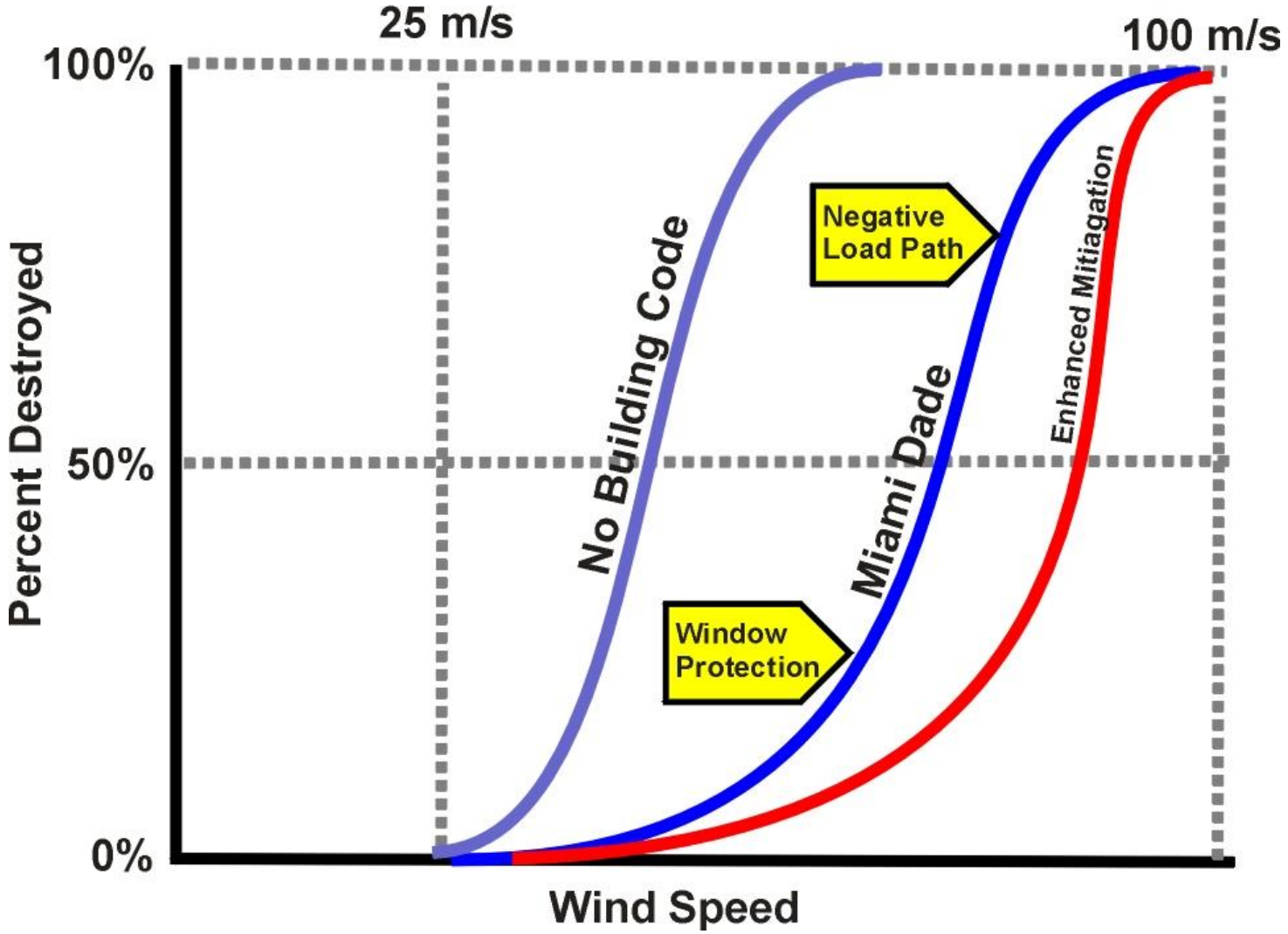


Where the Vulnerability Curve Starts to Ramp Up

Farther Up the Curve

Devastation

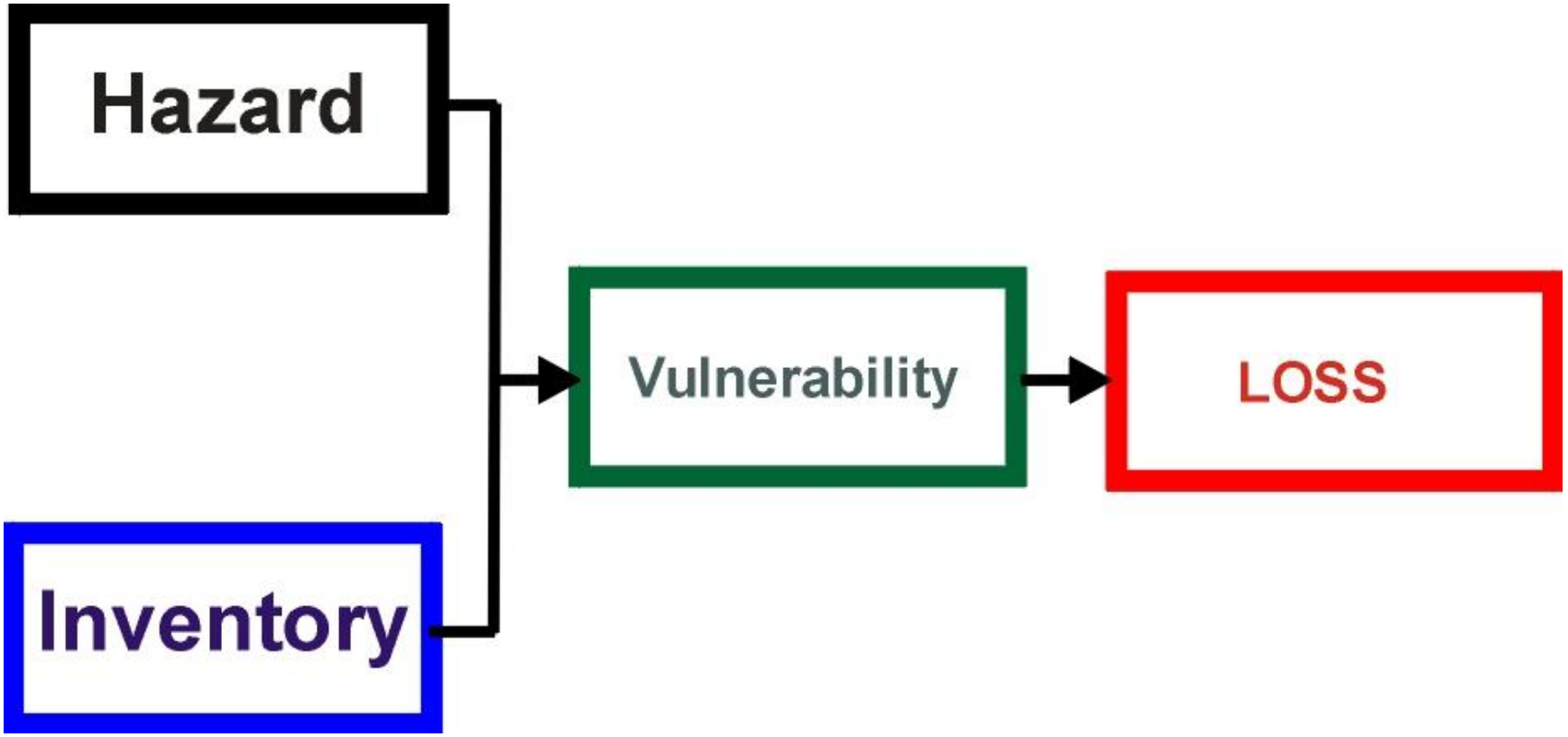
Schematic Effect of Construction Standards on Vulnerability



How Do Insurance Companies Set Rates?

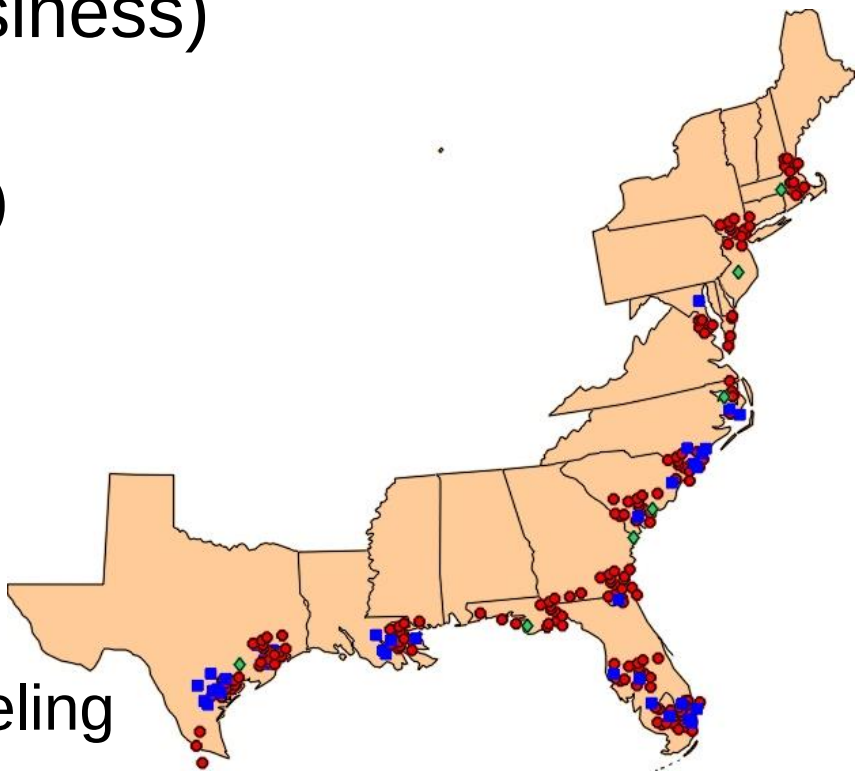
- Inventory of insured structures (***Book of Business***)
- Climatology of hurricanes
- Vulnerability curves for various kinds of construction
- Costs of claims based upon damage and terms of policies
- Regulation by state and federal governments

Structure of a Catastrophe (CAT) Model

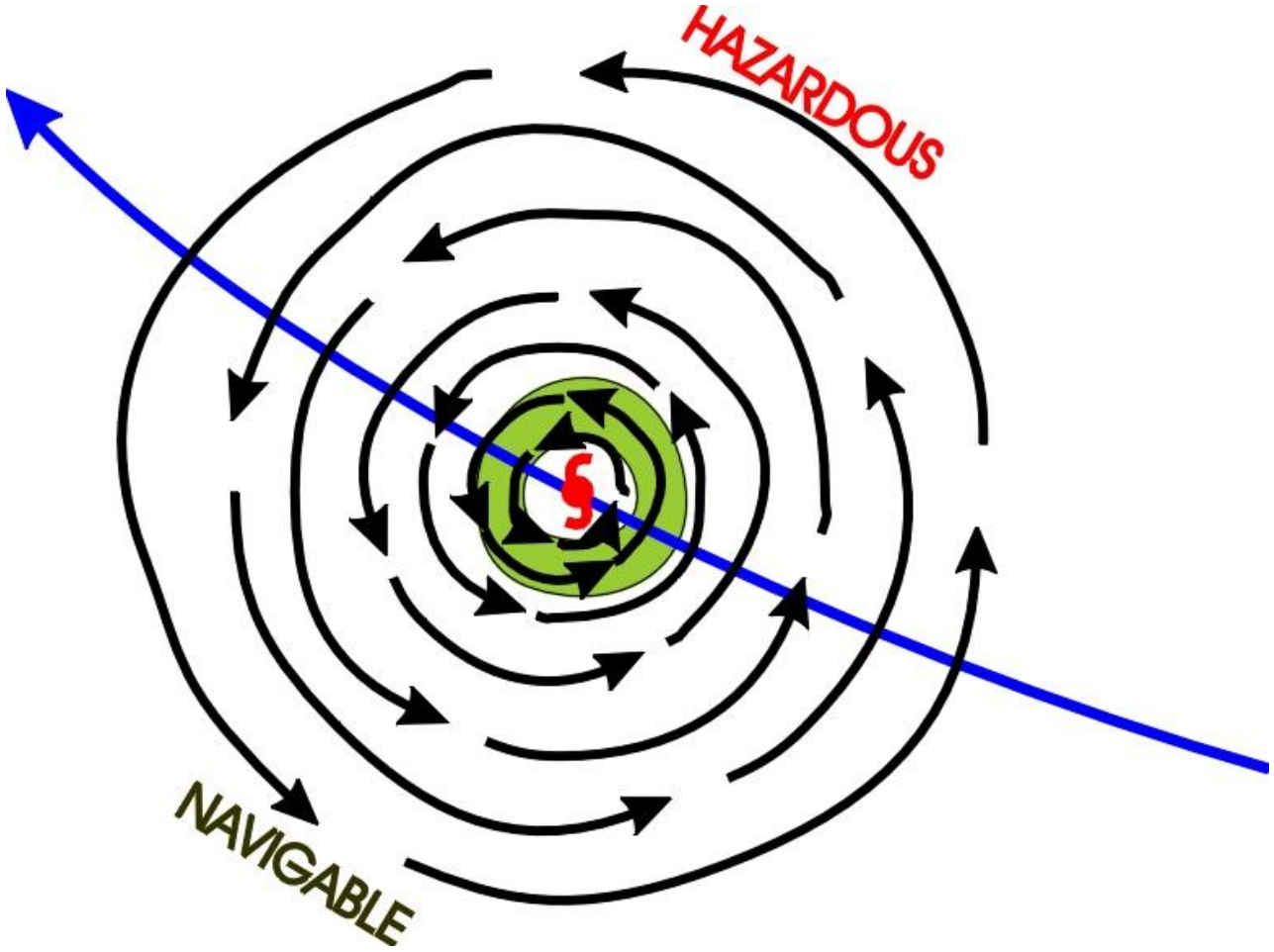


Inventory Module

- Digital list of insured structures (Book of Business)
- 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

```
64455 08/04/2005 M=15  9 SNBR=1334 IRENE       XING=0
64460 08/04*0000000   0    0*0000000   0    0*0000000   0    0*1290335  25 1009*
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64470 08/06*1720398  30 1008*1770405  30 1008*1820416  30 1008*1880428  30 1008*
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64585 08/27*2460833  90  959*2440840  95  950*2440847 100  942*2450853 100  948*
64590 08/28*2480859 100  941*2520867 125  930*2570877 145  909*2630886 150  902*
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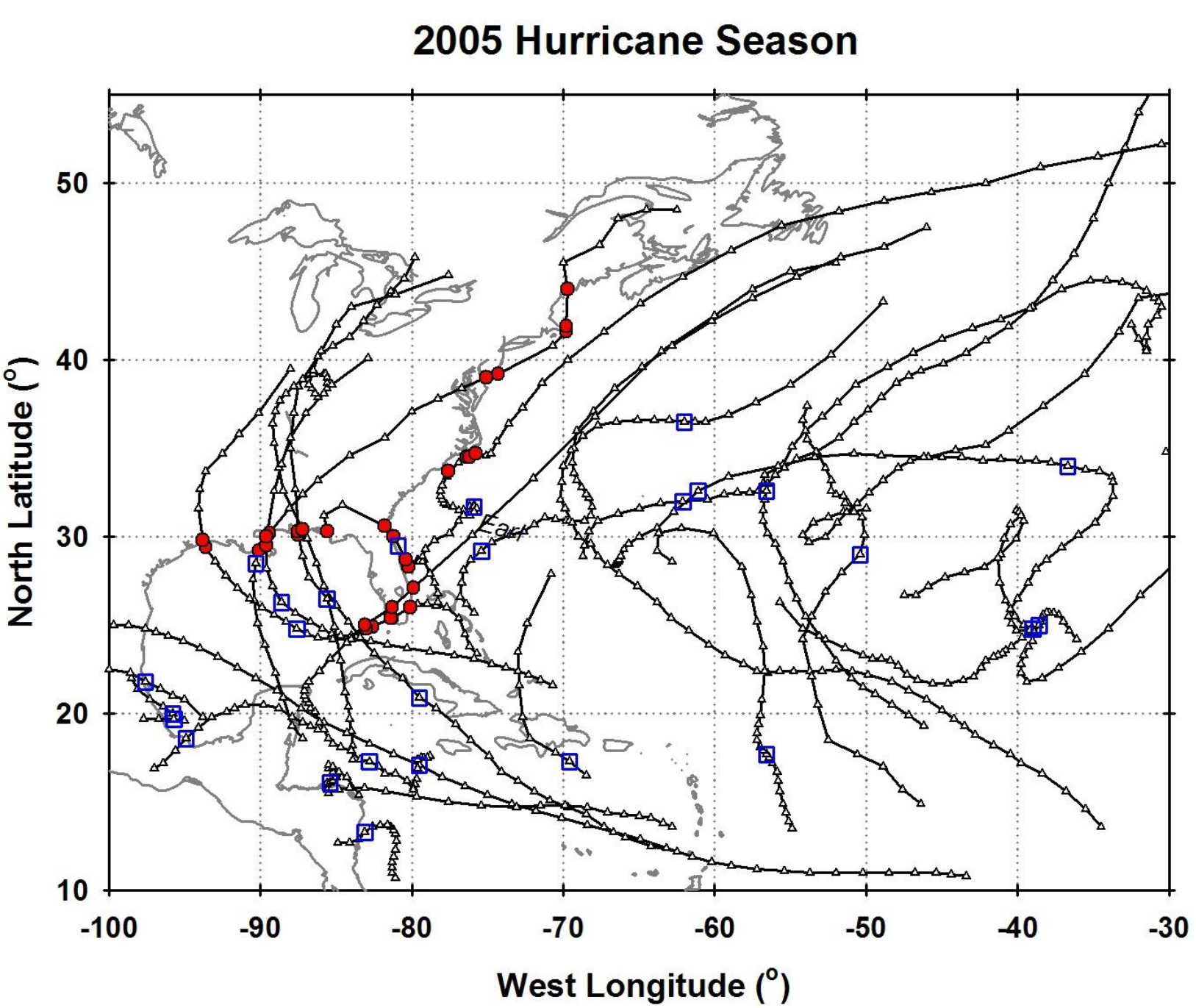
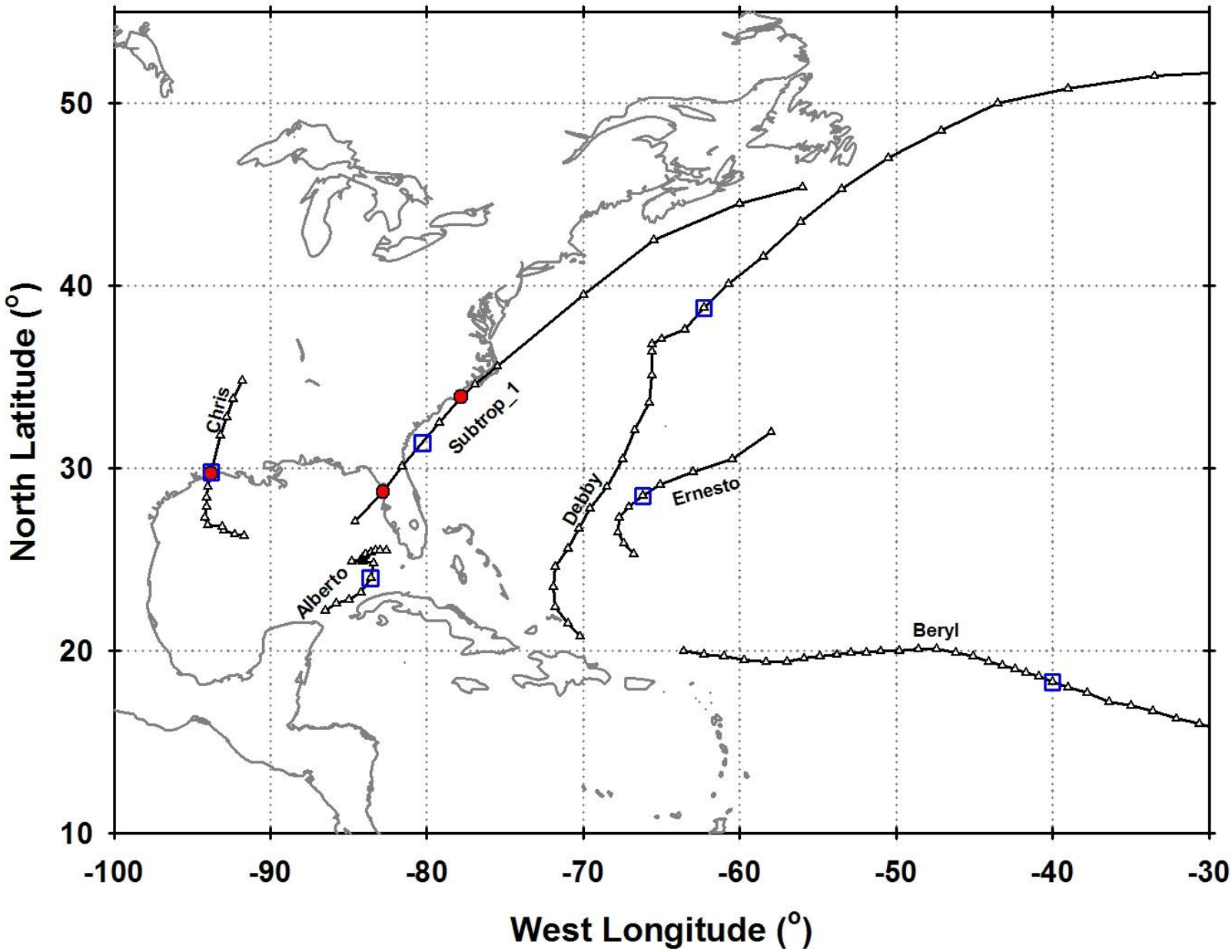
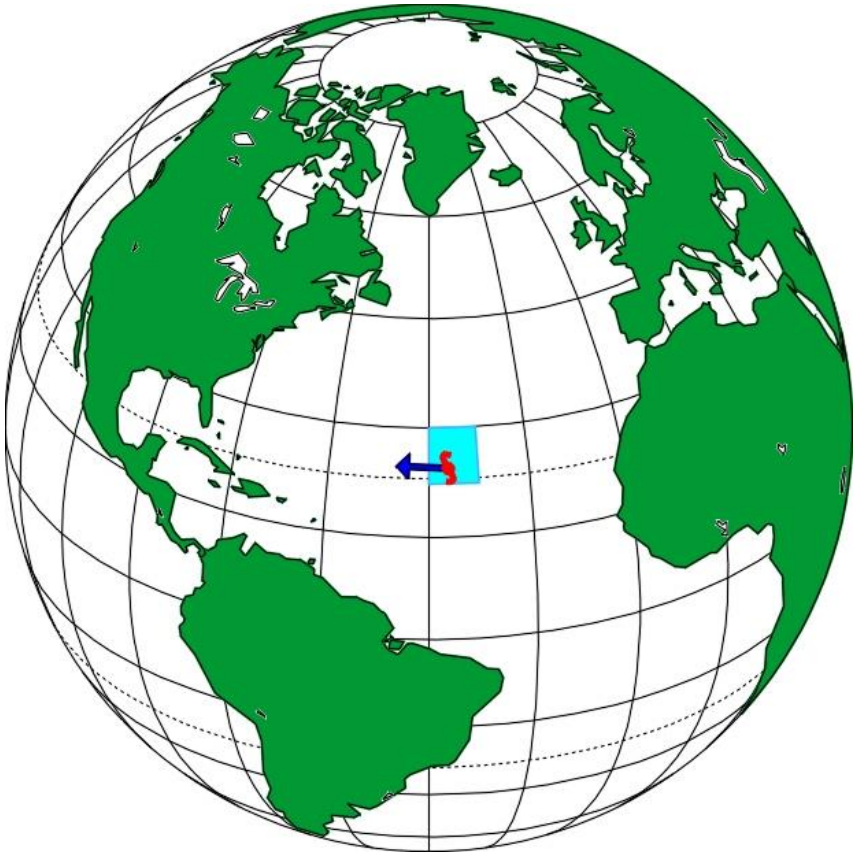

2005 Hurricane Season
North Latitude (°)
West Longitude (°)
50
40
30
20
10
-100
-90
-80
-70
-60
-50
-40
-30

1982 Hurricane Season



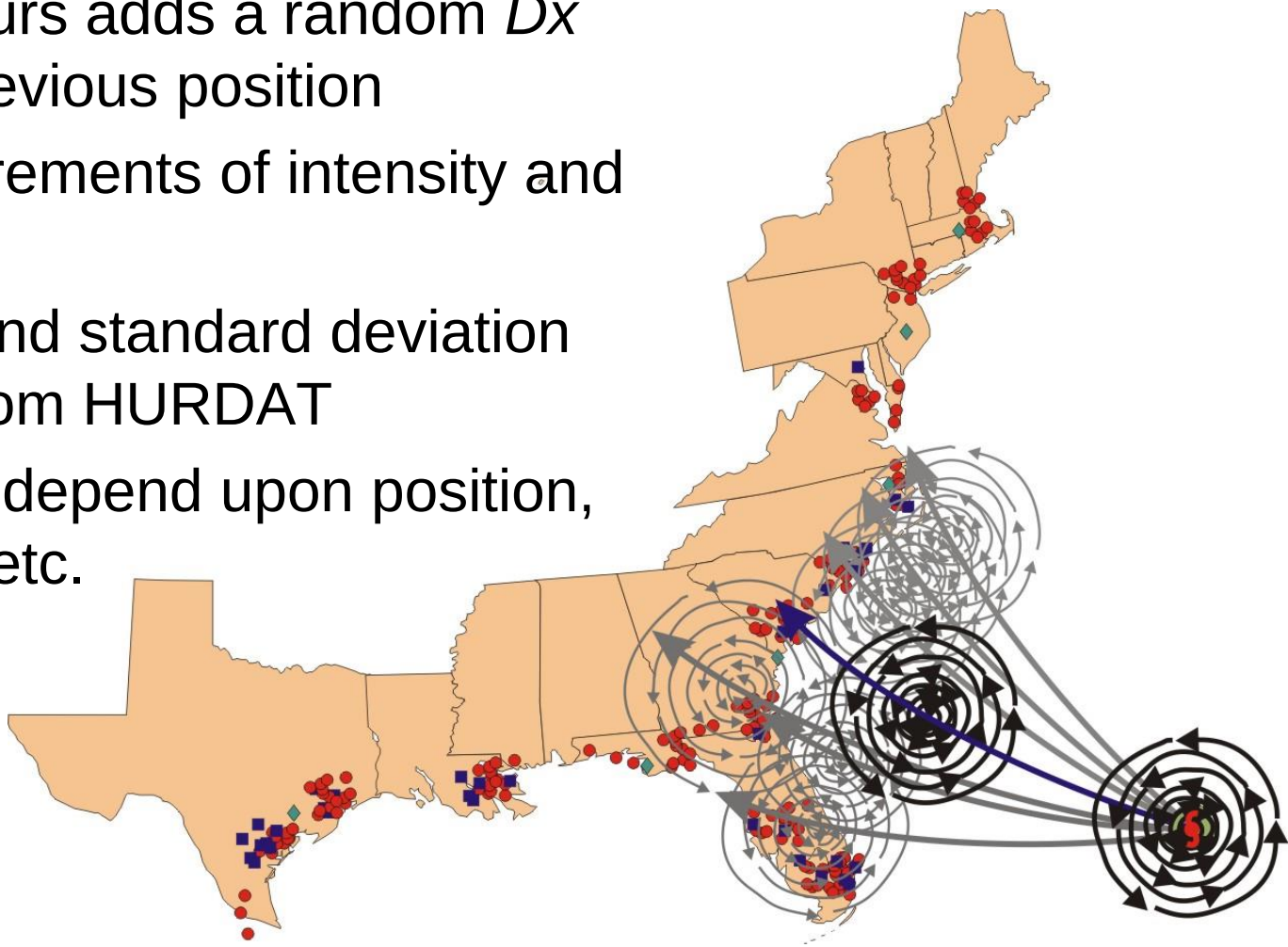
Synthetic Hurricane Seasons

- Generate ~1000 virtual hurricane seasons
- Go through each season day-by-day
- For each 10^{o} (or 5^{o}) 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



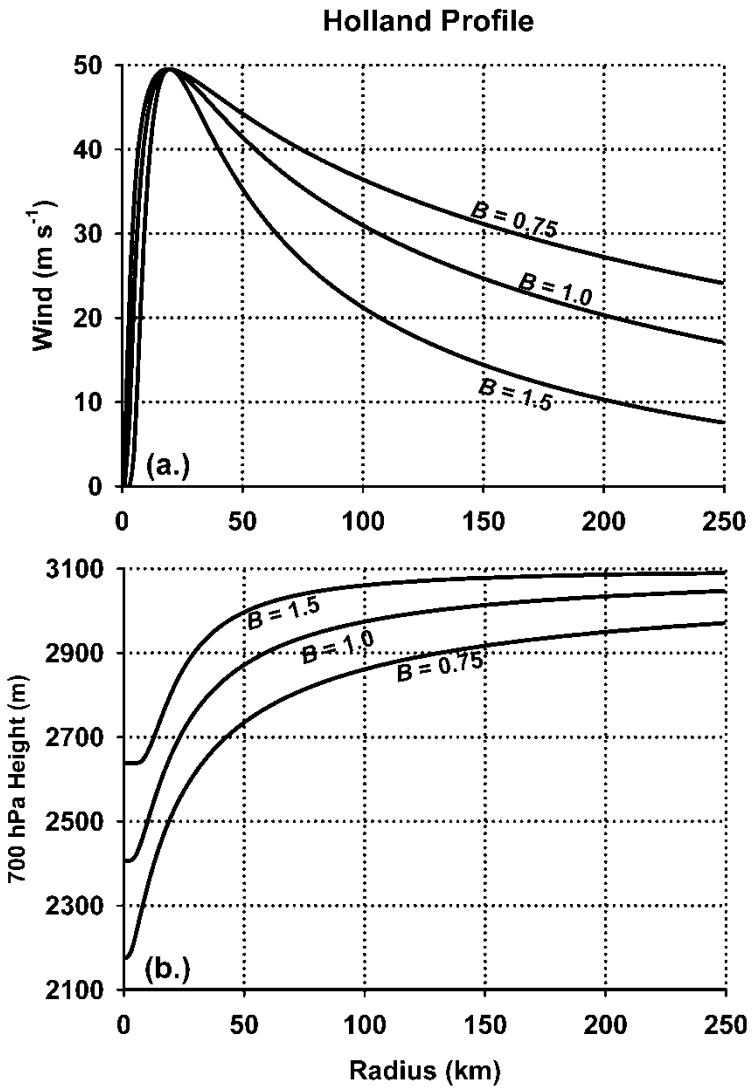
Model Track and Intensity Using a Markov Process

- 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.

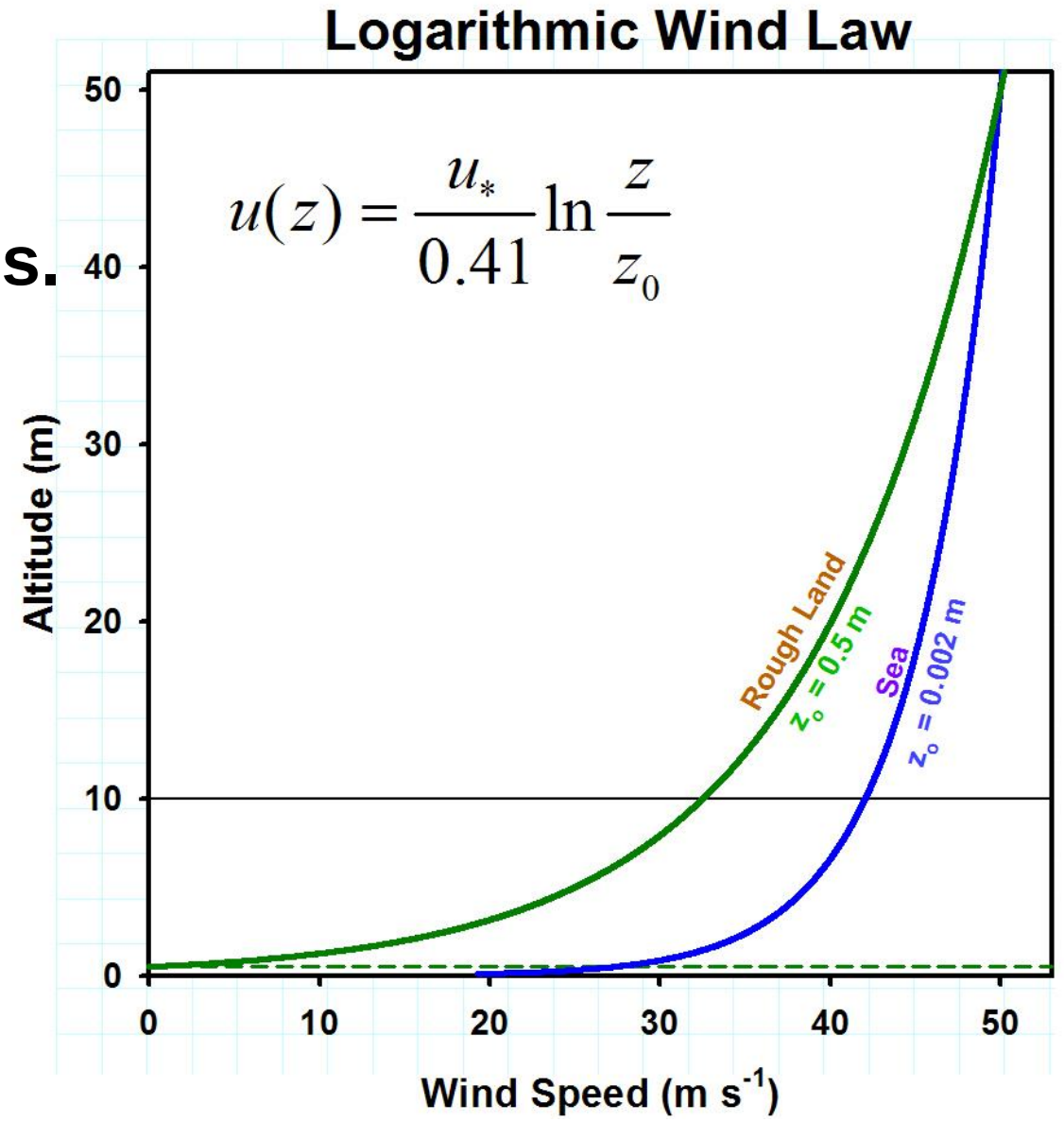


Many CAT Models Use the "Holland" Parametric Wind Profile

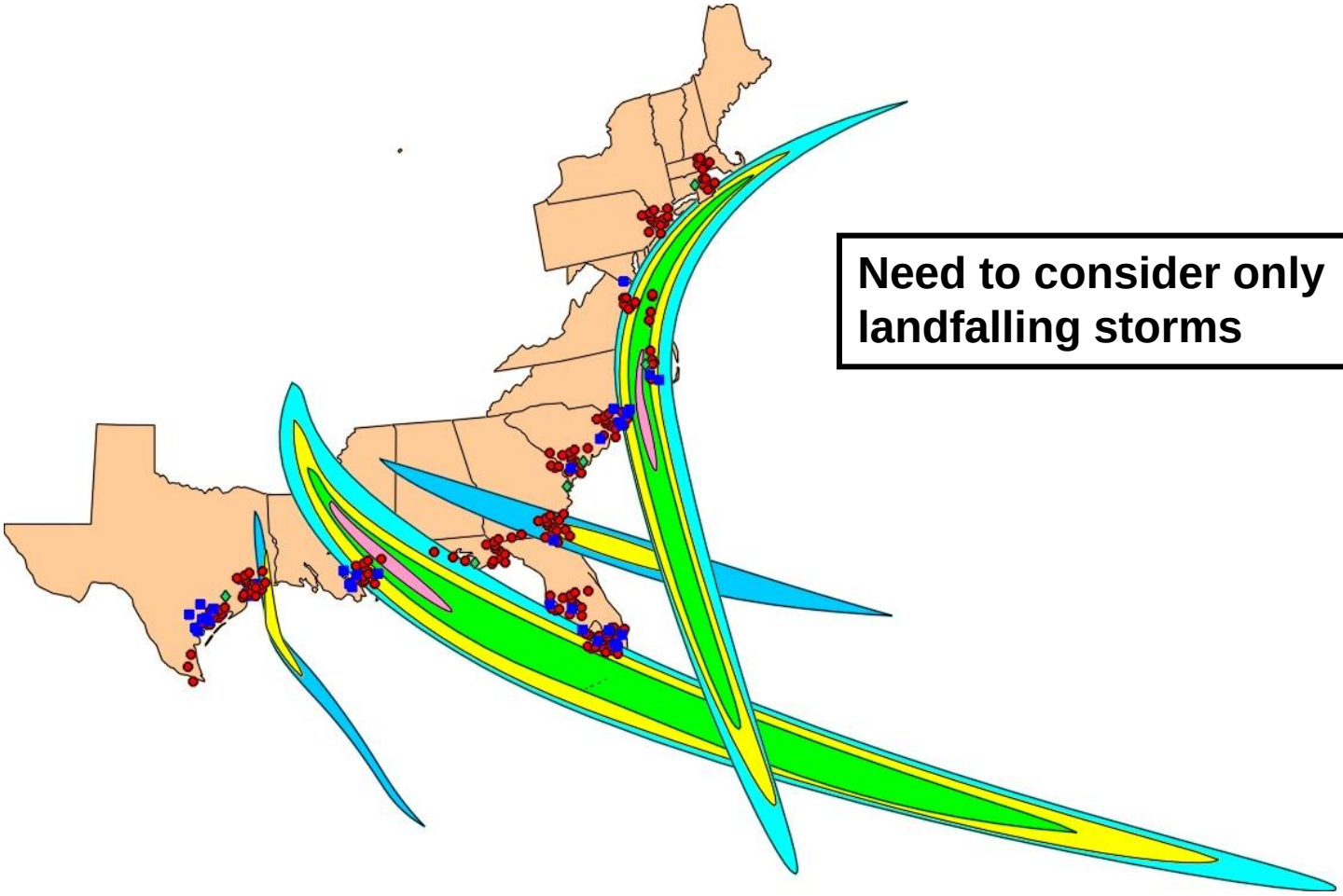
- Parameters are
  - Mimimum Pressure,
  - Radius of Maximum Wind
  - B, the "Width Parameter"
- Monte-Carlo model of changes
- Generate winds for each virtual hurricane



Vertical structure of the wind depends upon surface roughness.



Virtual Storms Impact on Actual Insured Property



Need to consider only landfalling storms

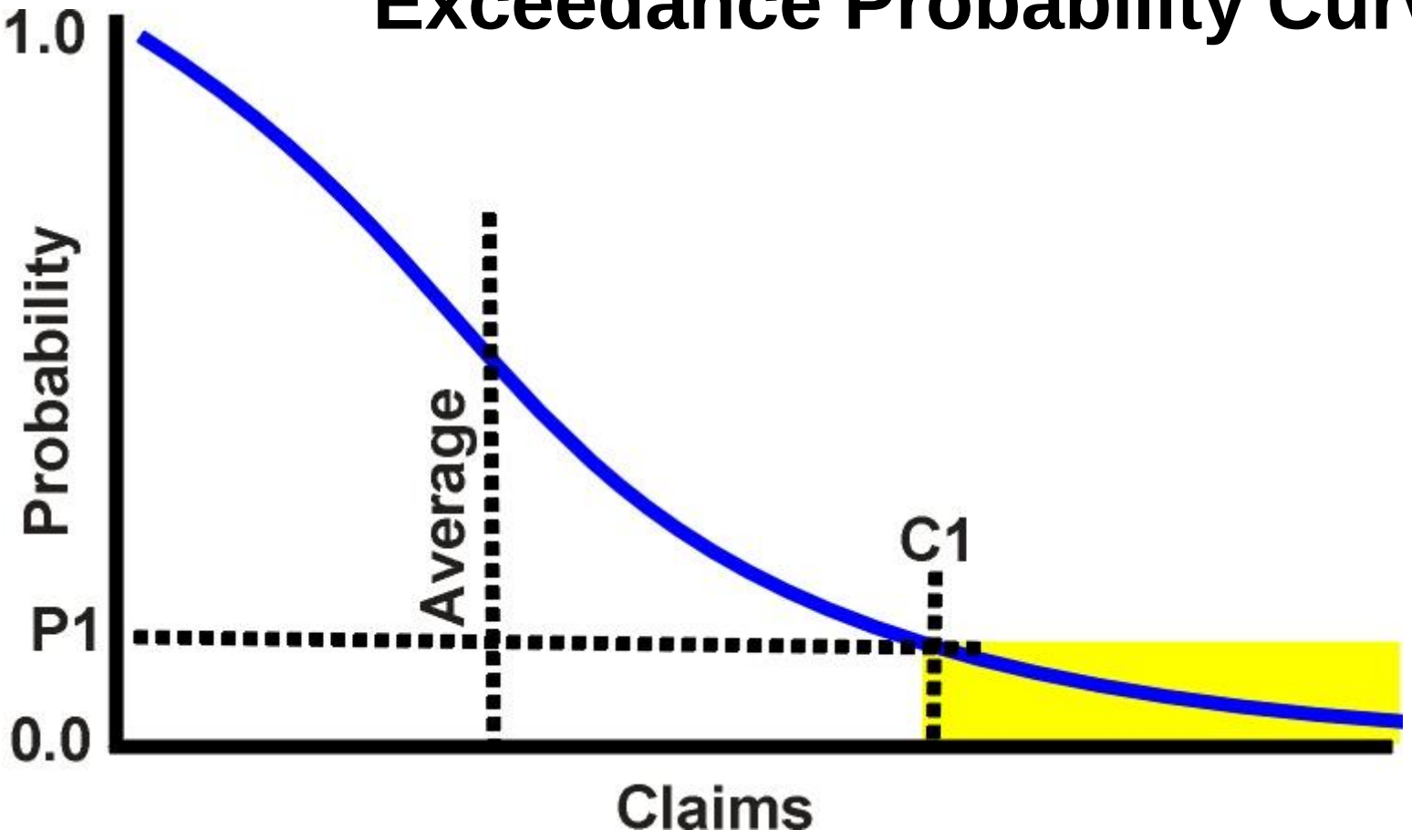
Cost Module

- 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

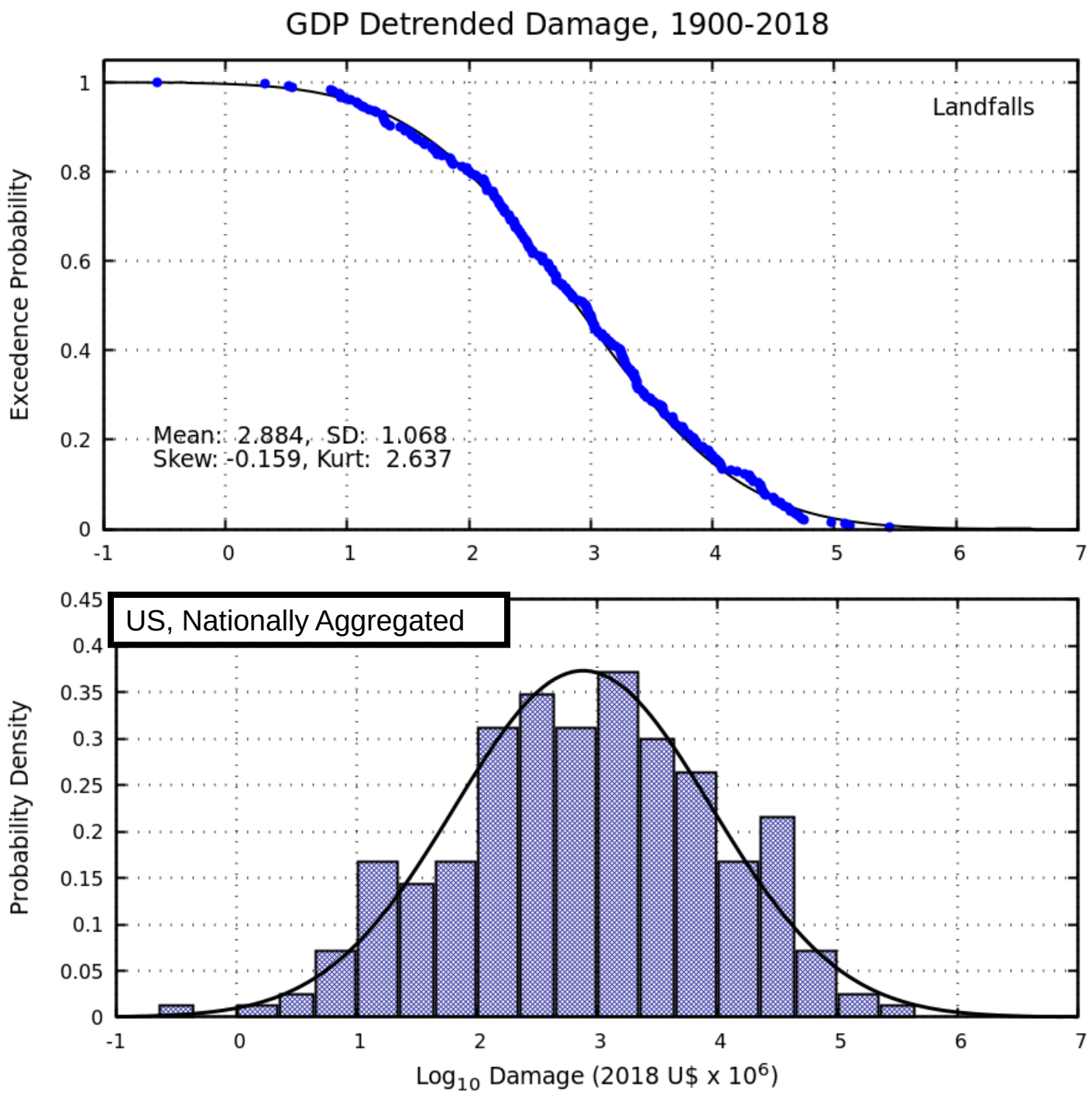
CAT Model Summary

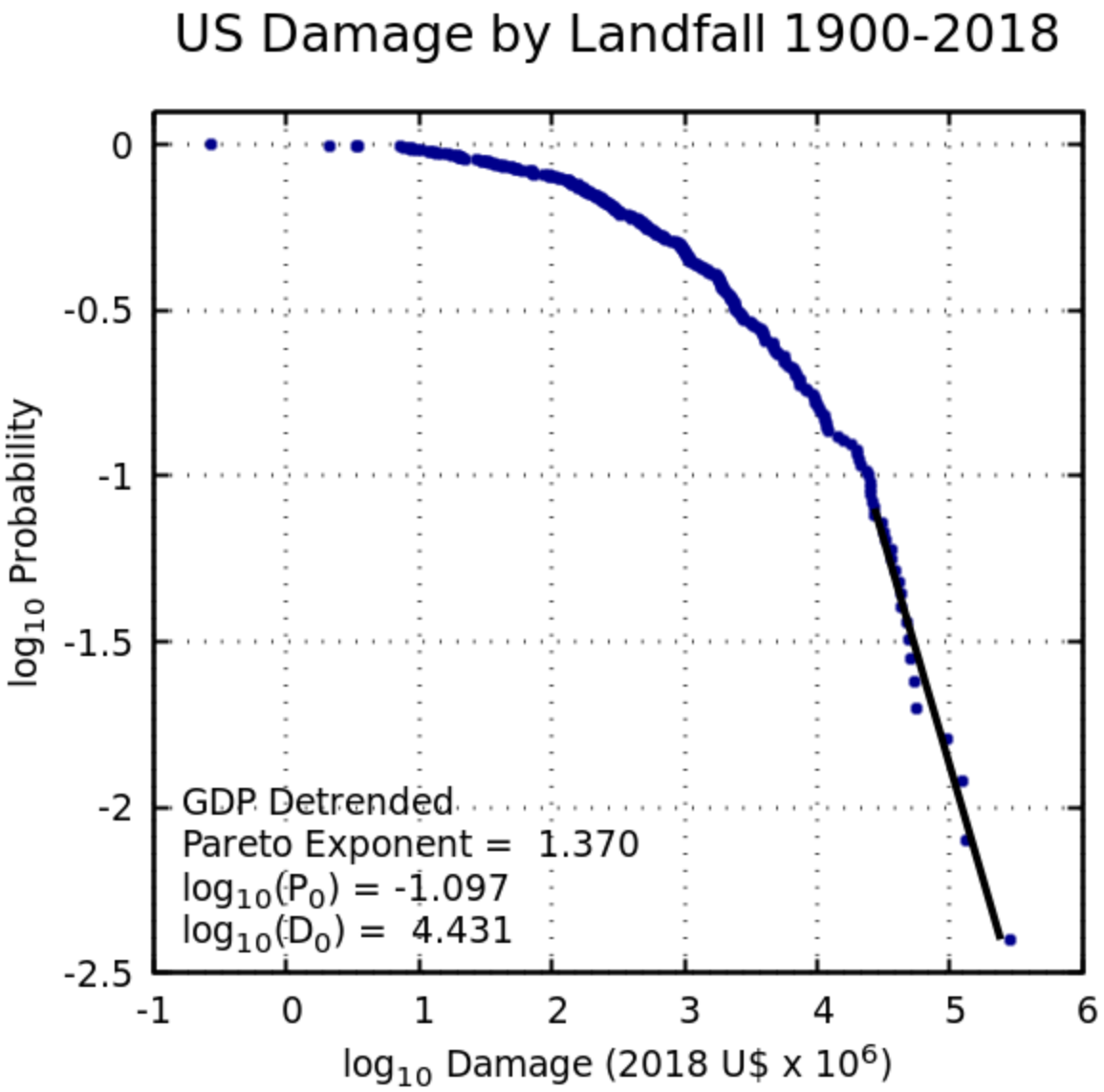
- Generate many (~1000) random hurricane seasons with the same climatology as HURDAT
- Calculate damage and claims for the company's Book of Business
- Count from most damaging to least damaging and sort from leat damaging to most damaging
- Divide count by number of seasons and tabulate as a function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

Exceedance Probability Curve



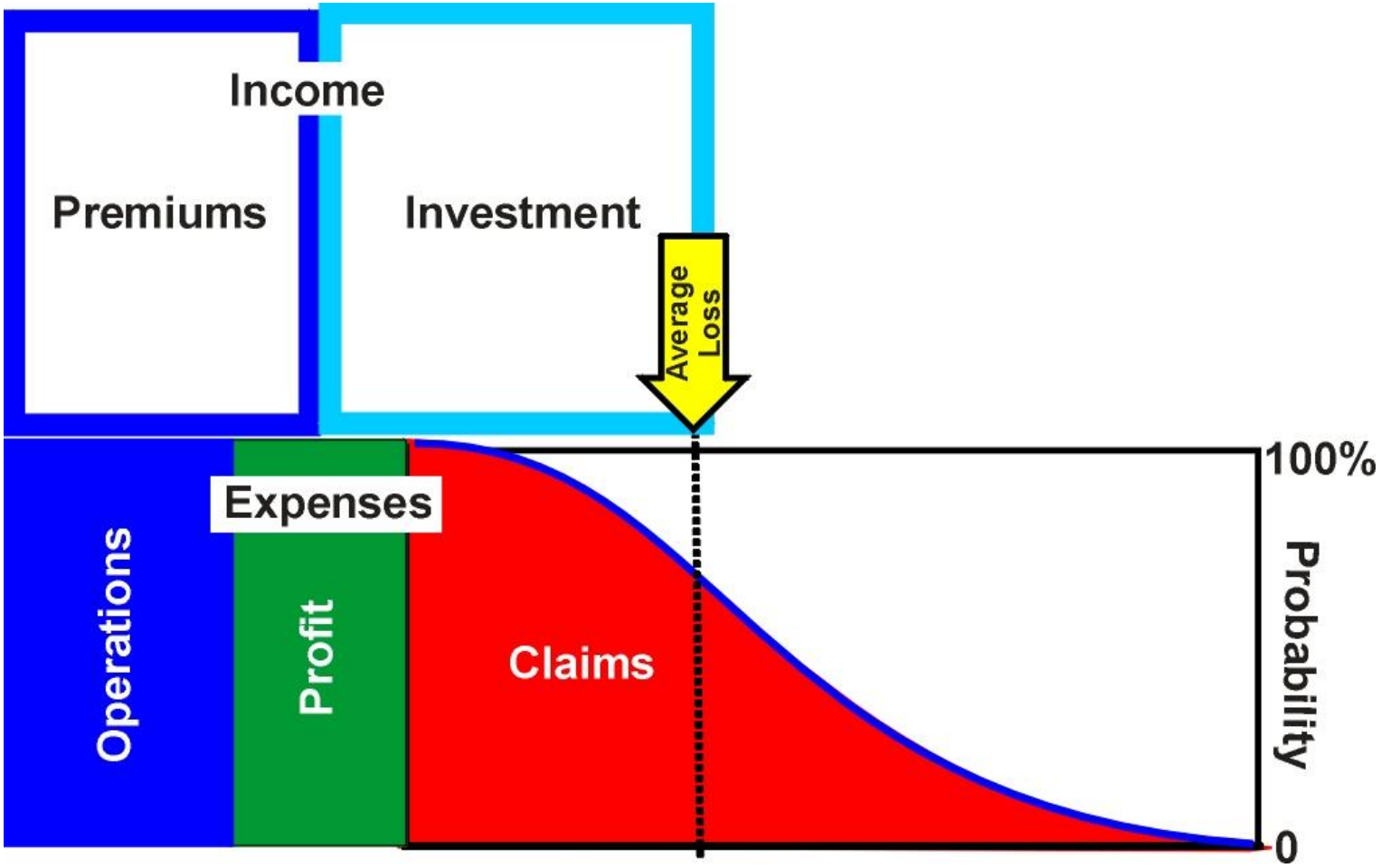
- The Curve gives the probability of each potential "Loss Cost" or greater


GDP Detrended Damage, 1900-2018
Landfalls
Excedence Probability
Mean: 2.884, SD: 1.068
Skew: -0.159, Kurt: 2.637
US, Nationally Aggregated
Probability Density
Log10 Damage (2018 U$ x 10^6)

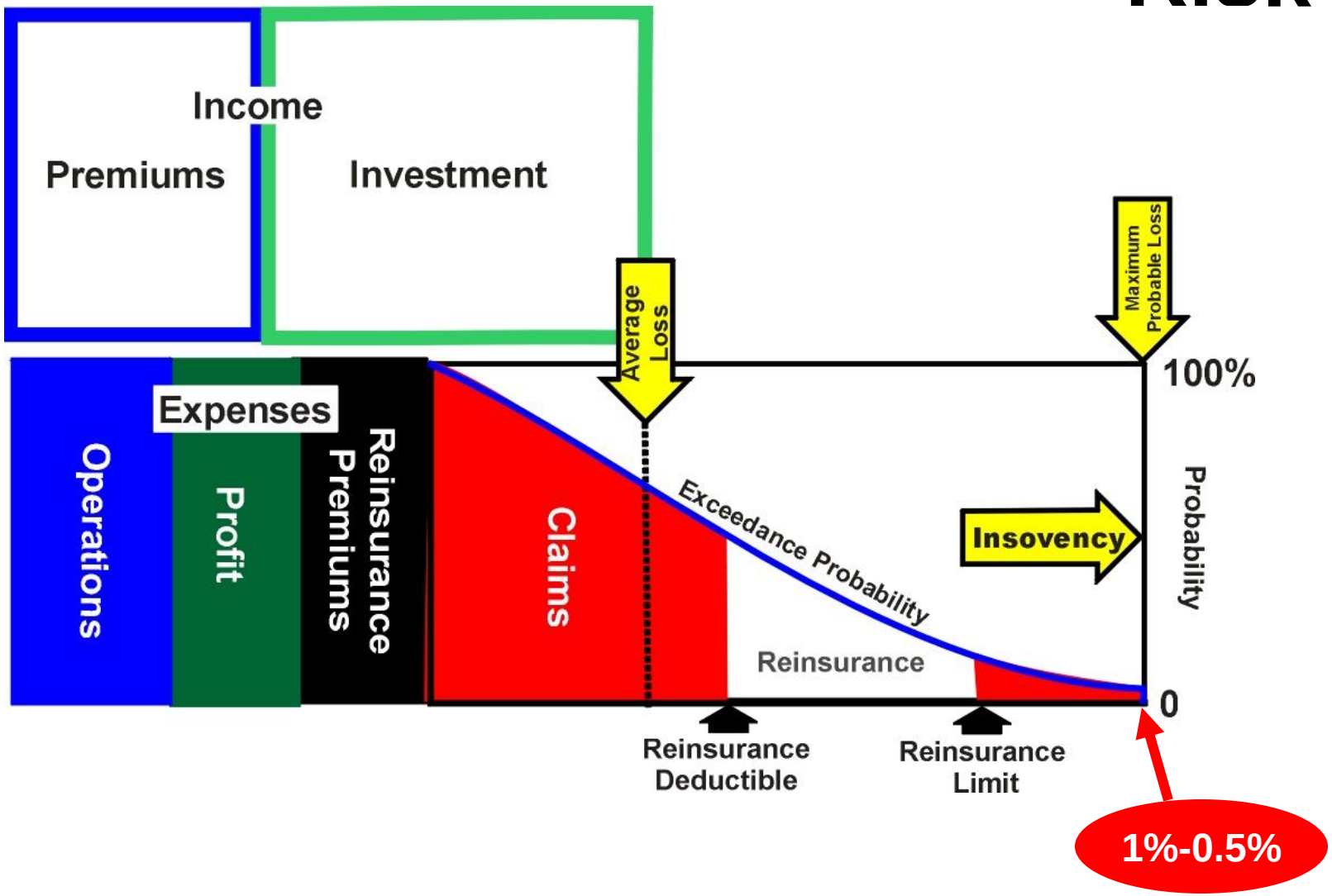


These are US nationally aggregated losses. Insurers will use their own “Book of Business”

How do Insurance Companies Use Exceedance Probabilities?



Reinsurance is Used to Transfer Risk



Study Questions

1. Most primary insurance companies buy _____ to protect themselves against catastrophic losses much greater than the annual average.
   a. Flood insurance
   b. Reinsurance
   c. PML
   d. Credit Default Swap

2. The ____ component of a Hurricane Catastrophe model relates wind speed or flood water depth to the fraction of an insured structure destroyed
   a. Vulnerability
   b. Hazard
   c. Loss
   d. Inventory

3. Probable Maximum Loss represents the largest expected total claims that a primary insurance company might pay during an unusually destructive year. PML typically has annual probability _____.
   a. 50%
   b. 33-66%
   c. 1-0.5%
   d. < 0.1%

4. Because of its fundamental nature, the reinsurance industry must be_____
   a. Cooked as hell
   b. Profitable every year
   c. Subject to local regulation
   d. International in scope

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


Thank you for
your attention.
Questions?