THE SCIENCE OF HURRICANE MODELING

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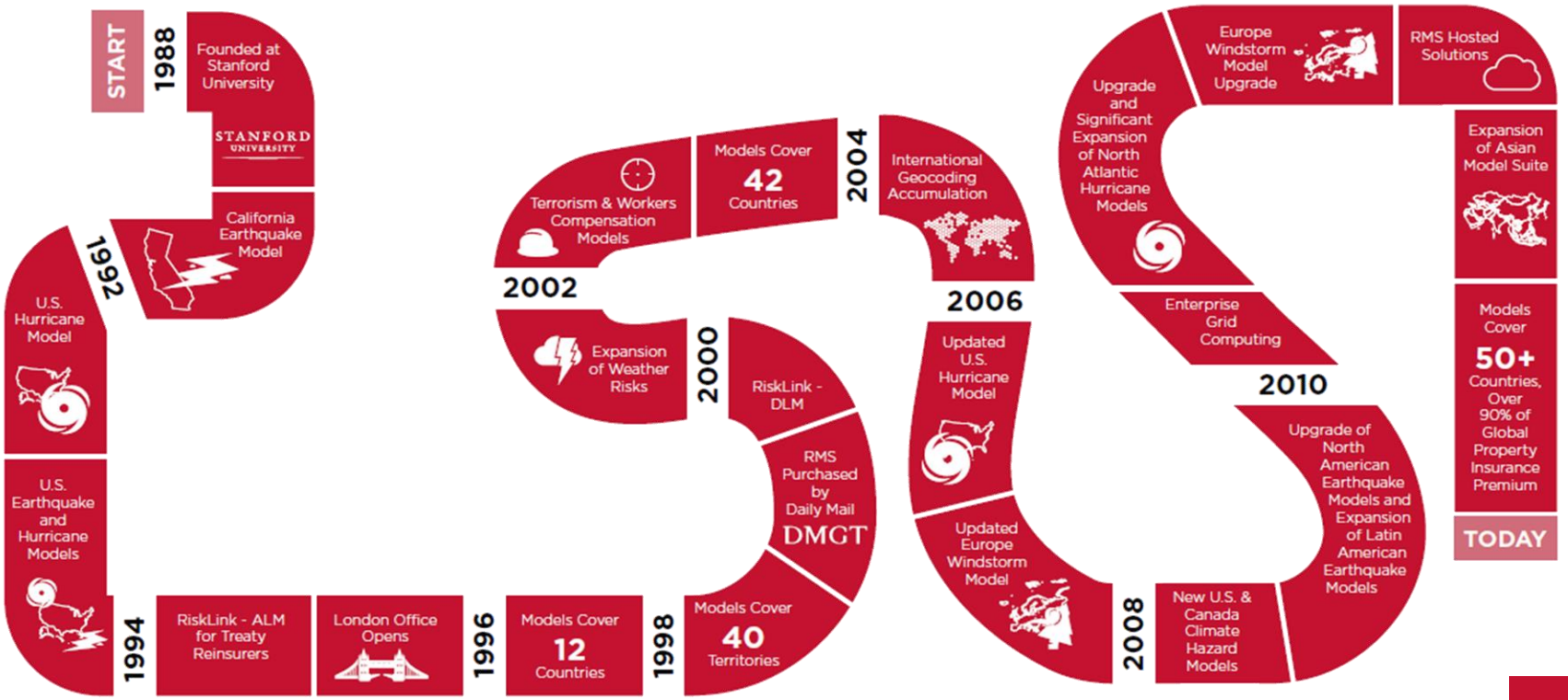
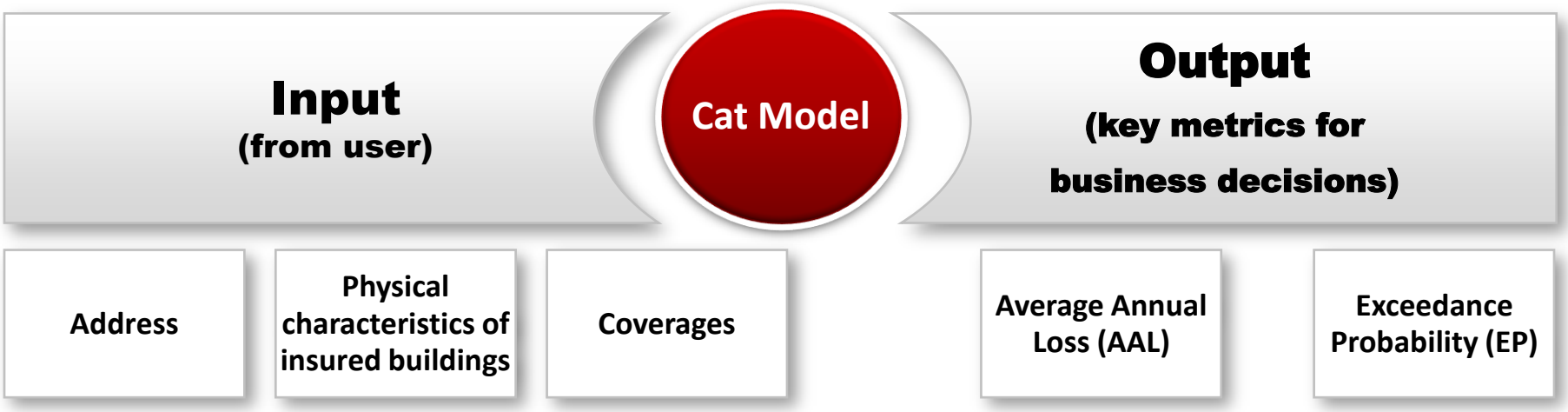
OUR HISTORY



WHY DO WE NEED A MODEL?

CATASTROPHE MODELS

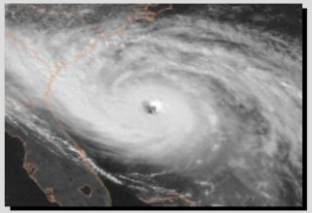


Where do we start?

- The historical record is a good starting point, but…
  - Records are incomplete both spatially and temporally
  - There is no way to determine a 500 year event in the US
  - Assumes that all future events will mimic history, which inadequately prepares businesses for new events
    - E.g. Tropical Storm Allison, Hurricane Katrina, Superstorm Sandy
- Create a model that can simulate thousands of years worth of events
  - Need the ability to reflect historical events, but allow for events we haven't experienced
  - Provide scenarios for the 'big ones'

The Science Behind a Model

Cat models are typically structured into various components that mimic the process of estimating hurricane risk to a portfolio.



Define Hurricane

Stochastic Event Module

Assess Wind Speed

Hazard Module

Apply Exposure

Geocoding/ Exposure Module

Calculate Damage

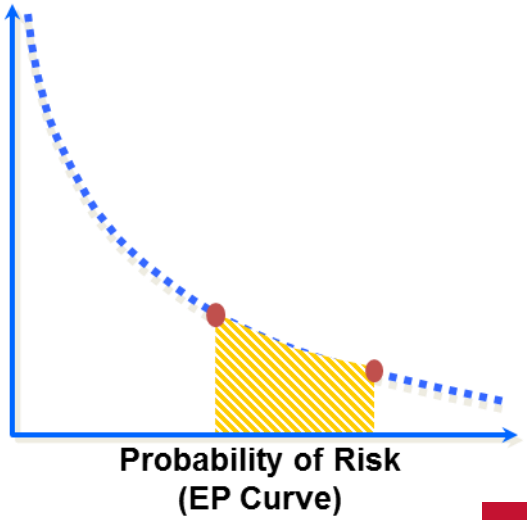
Vulnerability Module

Quantify Financial Loss

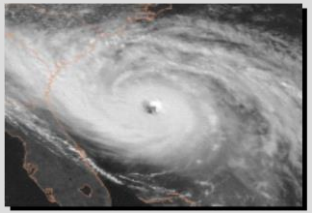
Financial Analysis Module

What do we need to build a model?

- Stochastic
  - Information on storm frequency and intensity from historic reports and industry claims data
  - Hurricane characteristics from HURDAT (e.g. Rmax)
  - Paleotempestology, other pre-historic analysis
- Hazard
  - Historic wind damage reports
  - Windfield models/physical simulations
  - Surface roughness and topography
- Vulnerability
  - Engineering reports to relate windspeed to damage
  - Industry claims
- Financial
  - Policy information



FRAMEWORK FOR MODELING A HURRICANE



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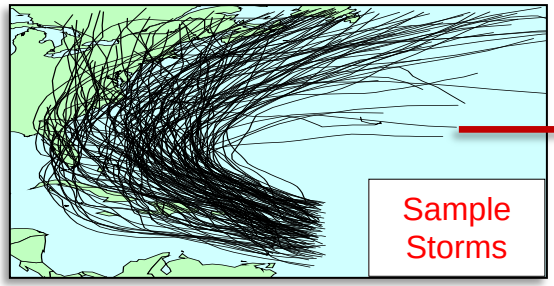
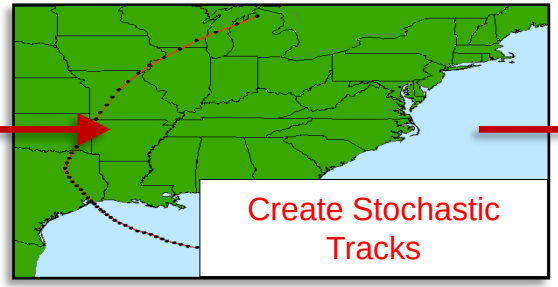
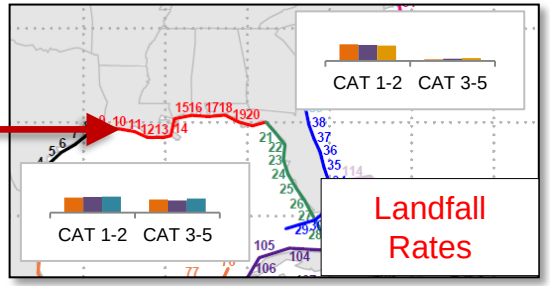
STOCHASTIC EVENT MODULE







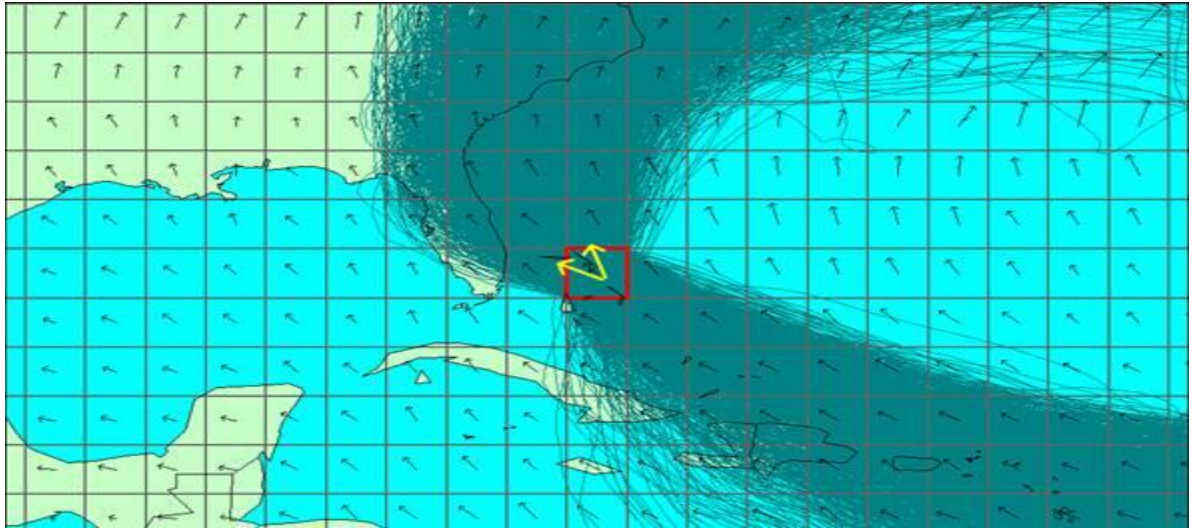
Use History to Understand Storm Characteristics

Create Synthetic Storms

Establish Frequency

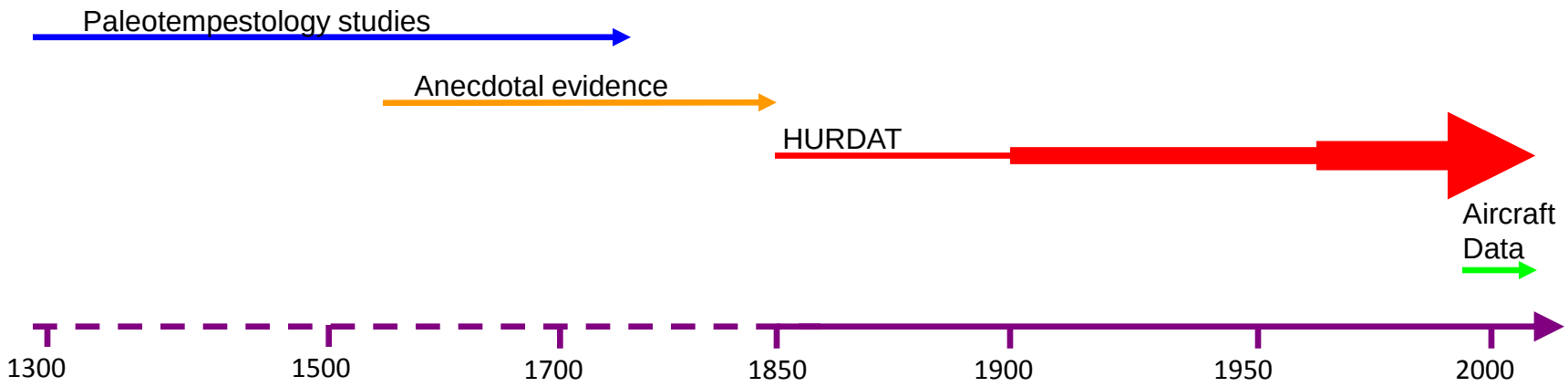
Basin-Wide Hurricane Track Set Simulation

- Use random-walk model to simulate fixed storm track set
  - Calibrate model over water based on historic crossings in cells
  - Calibrate model at coastline based on historic crossing rates and forward speed distributions along linear coastal segments

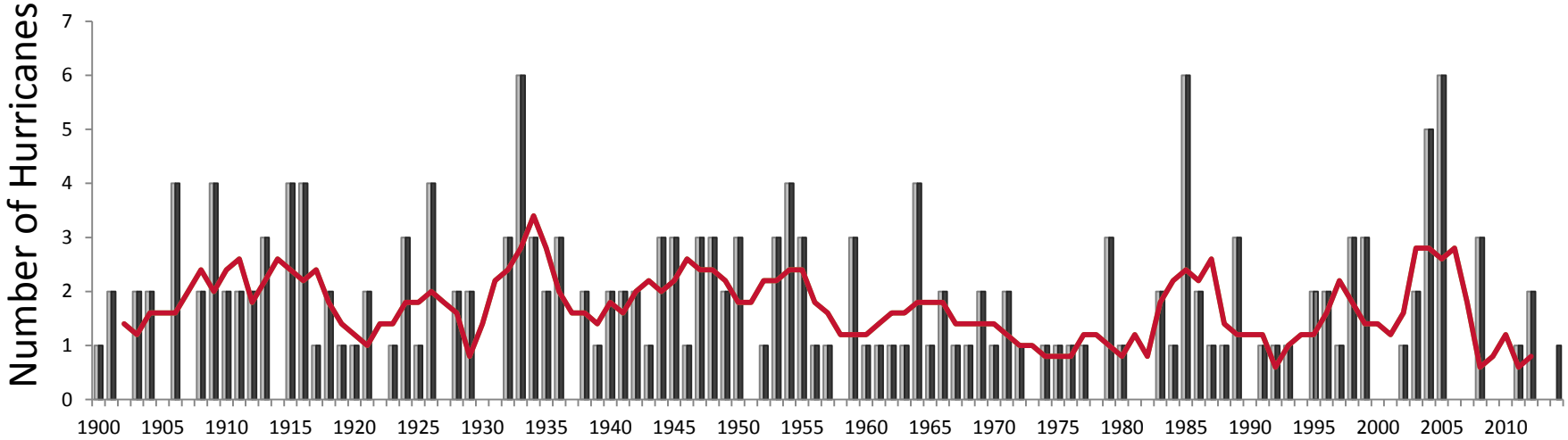


Developing an Historical View of Frequency

- Various data sources have been used to help inform the stochastic track development process
- HURDAT is widely recognized as the best source of track and intensity data – this is the backbone for the model



U.S. Hurricane Landfalls: HURDAT Data



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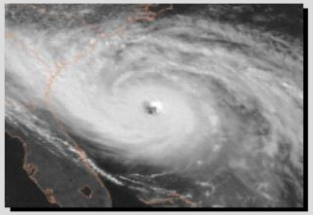

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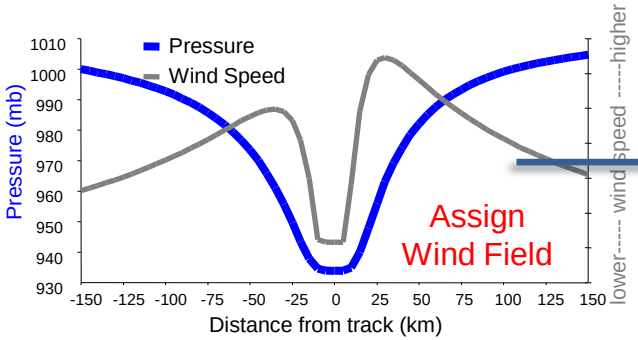
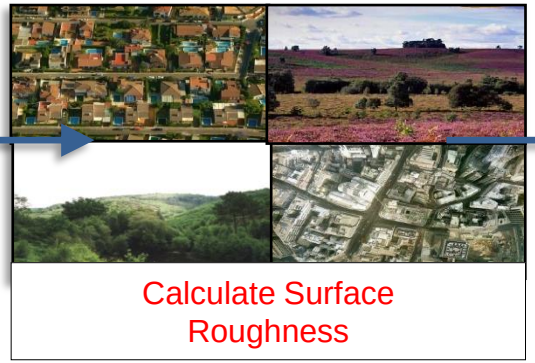
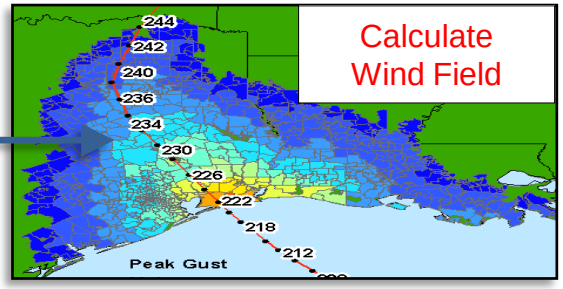
HAZARD MODULE





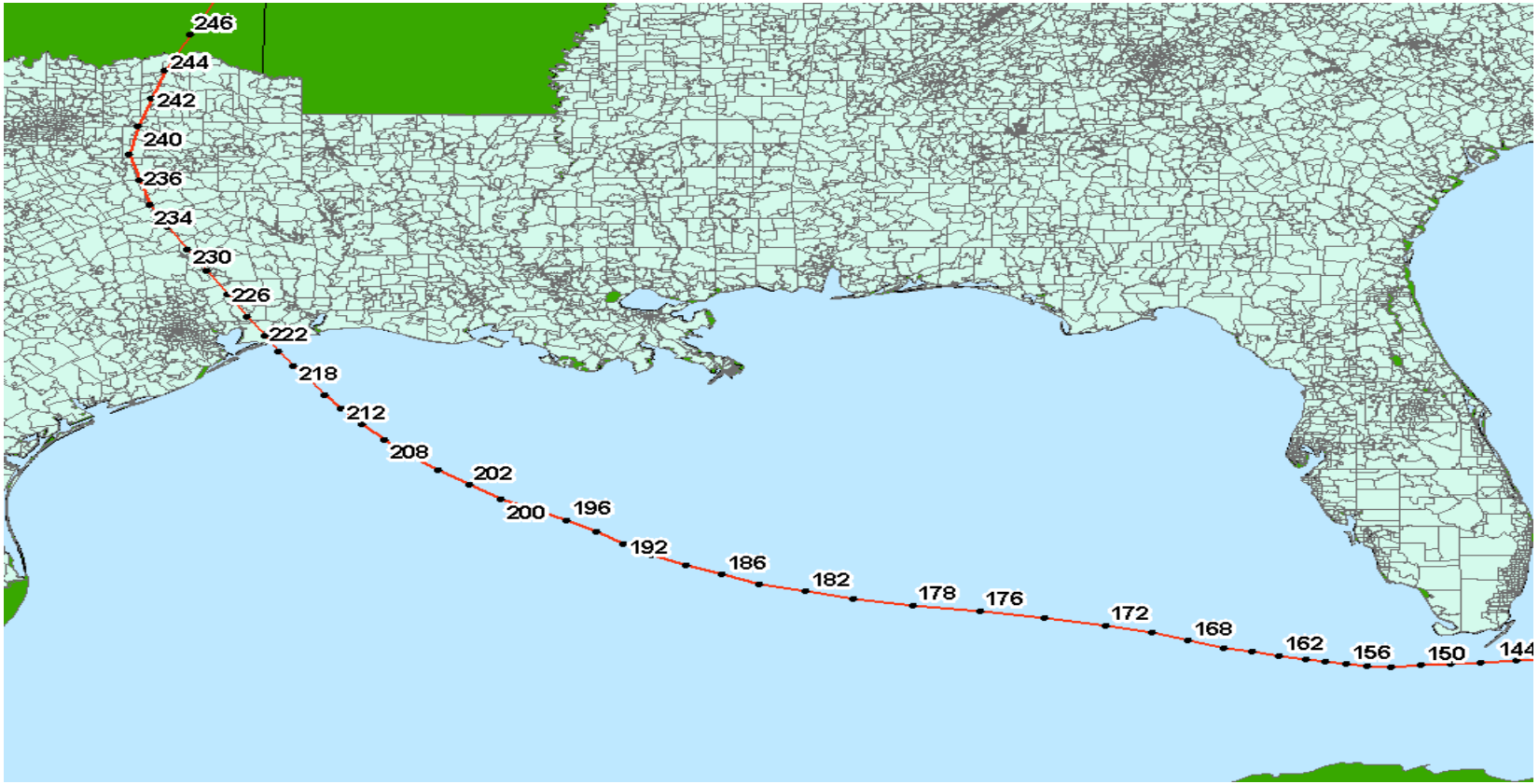


Use storm track to simulate wind field

Adjust the wind for local terrain

Determine wind speed for each location for each simulated storm

U.S. Hurricane: Time-Stepping Windfield Example



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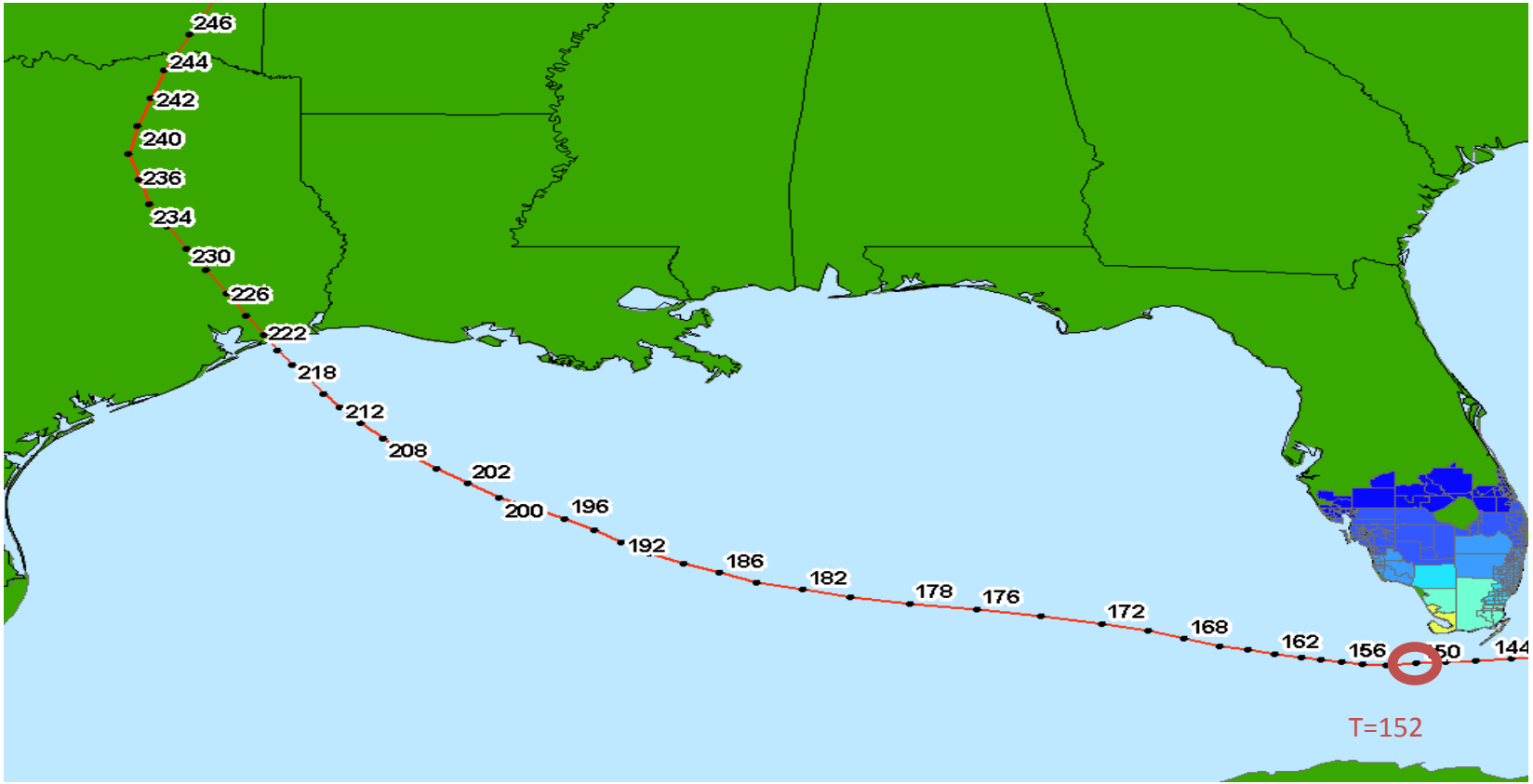

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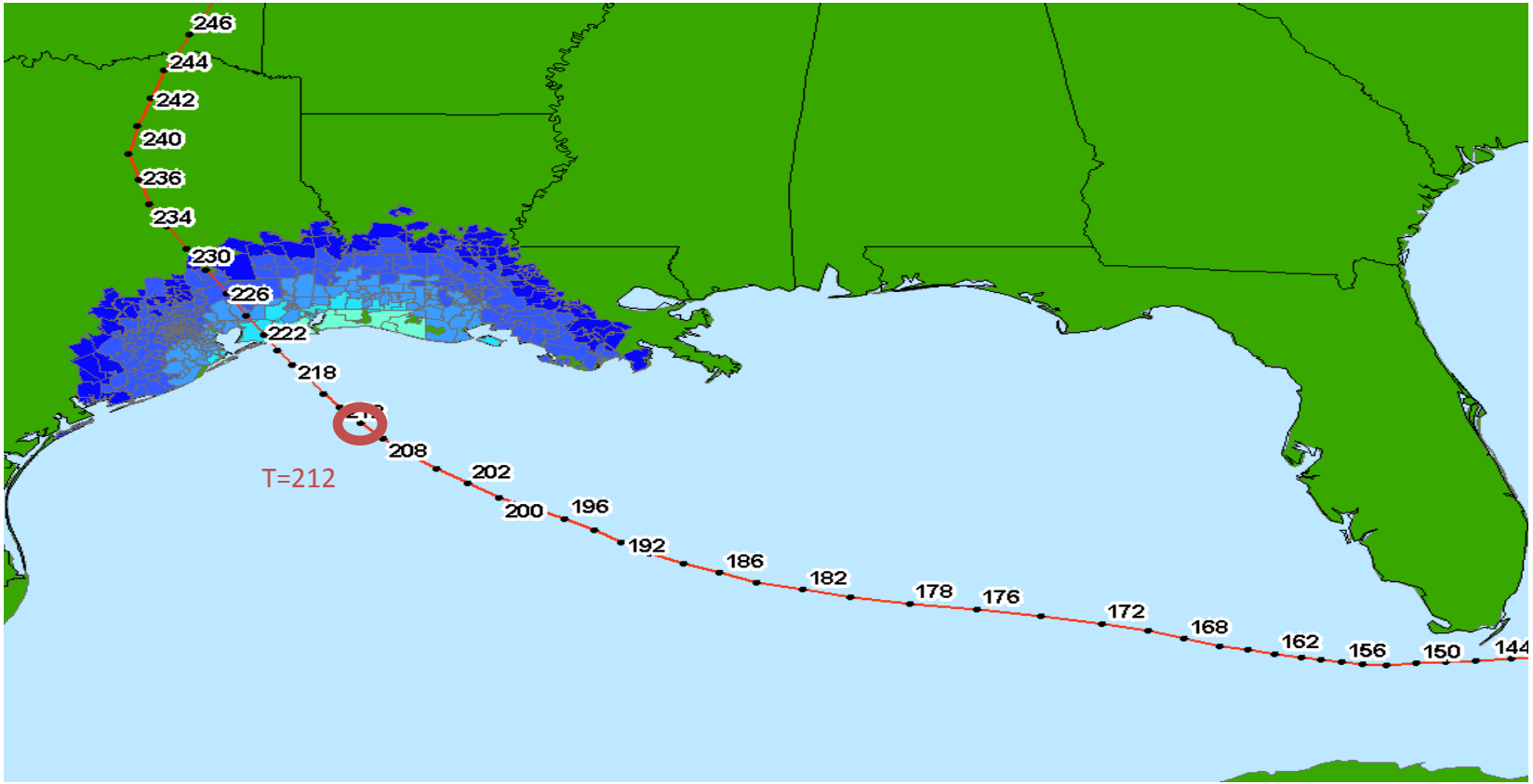

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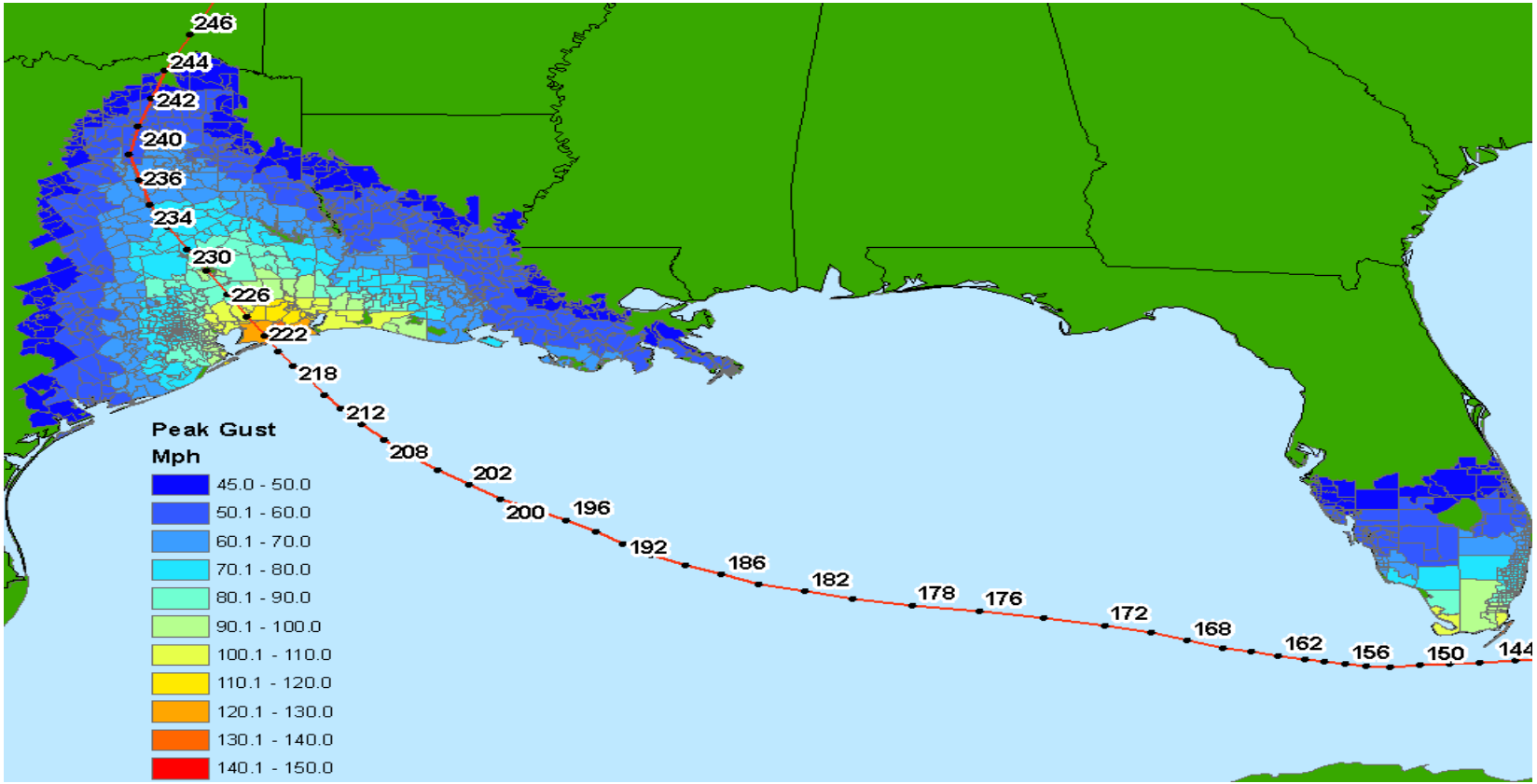
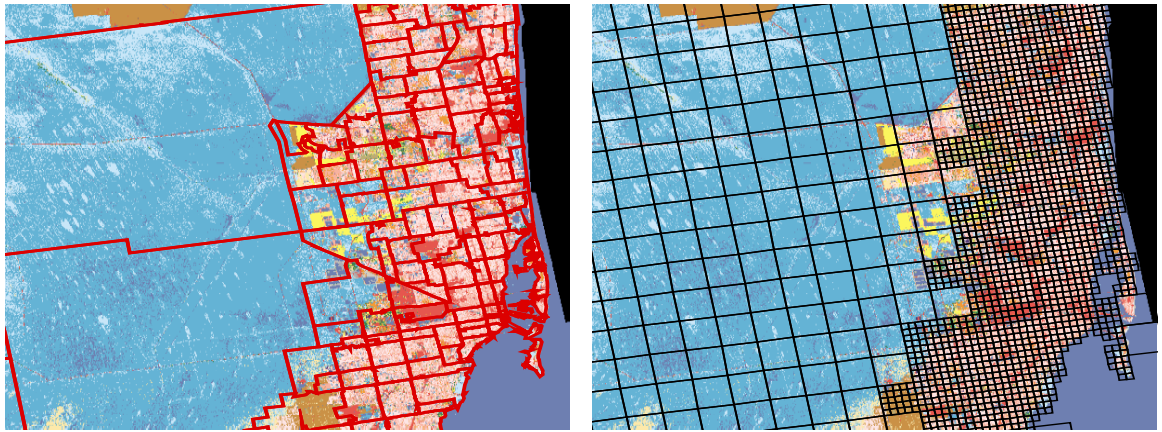


Variable Resolution Grid (VRG): Higher Resolution Hazard and Loss Modeling

- VRG makes it possible to model at high resolution without needing to make simplifying assumptions about loss gradients.
- Highest resolution cells are in areas of high exposure (major metropolitan areas) and high hazard (coastal regions)



Miami: ZIP Code vs. VRG Cell Sizes

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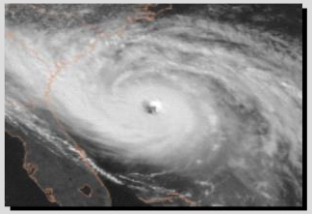

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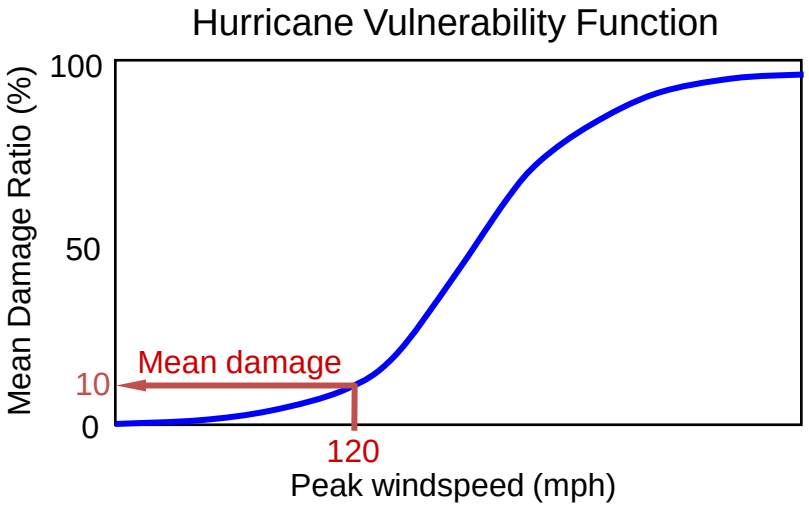
EXPOSURE AND VULNERABILITY

- A vulnerability function relates the expected amount of damage to the severity of the hazard, such as the peak windspeed.



A building's vulnerability at a given hazard intensity is measured by its mean damage ratio

$$MDR = \frac{\text{average loss}}{\text{replacement value}}$$

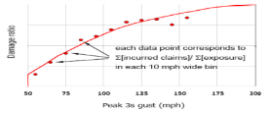
Understanding Development Process for Vulnerability

Information sources used including:

- Claims data
- Historical reconstructions of industry losses
- Building code comparisons
- Input from engineering consultants on construction quality
- Third-party engineering reports
- Post-event reconnaissance observations
- Engineering analytical models

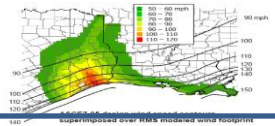
The weight assigned to each of these sources of information varies by region and is dictated by the amount and type of data that is available.

Detailed Claims Data

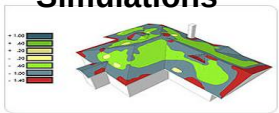


Bldg envelope failure mode

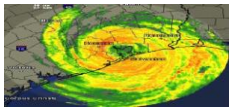
Building Codes



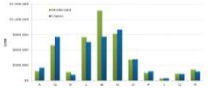
Bldg Element Simulations



Historical PCS/Claims



Model review process



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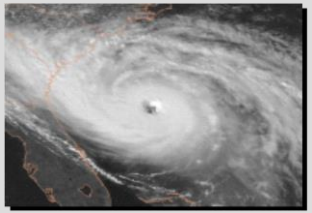

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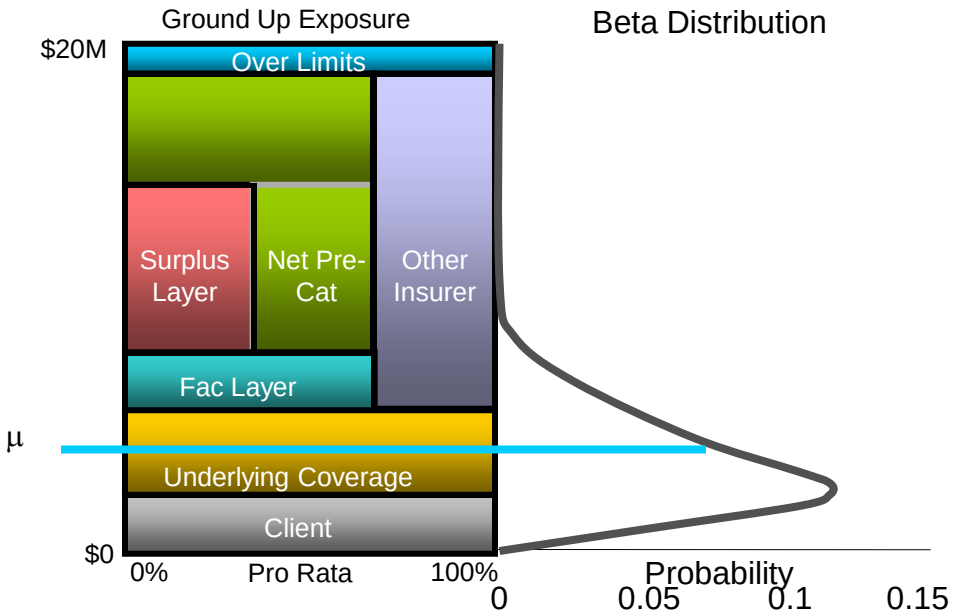
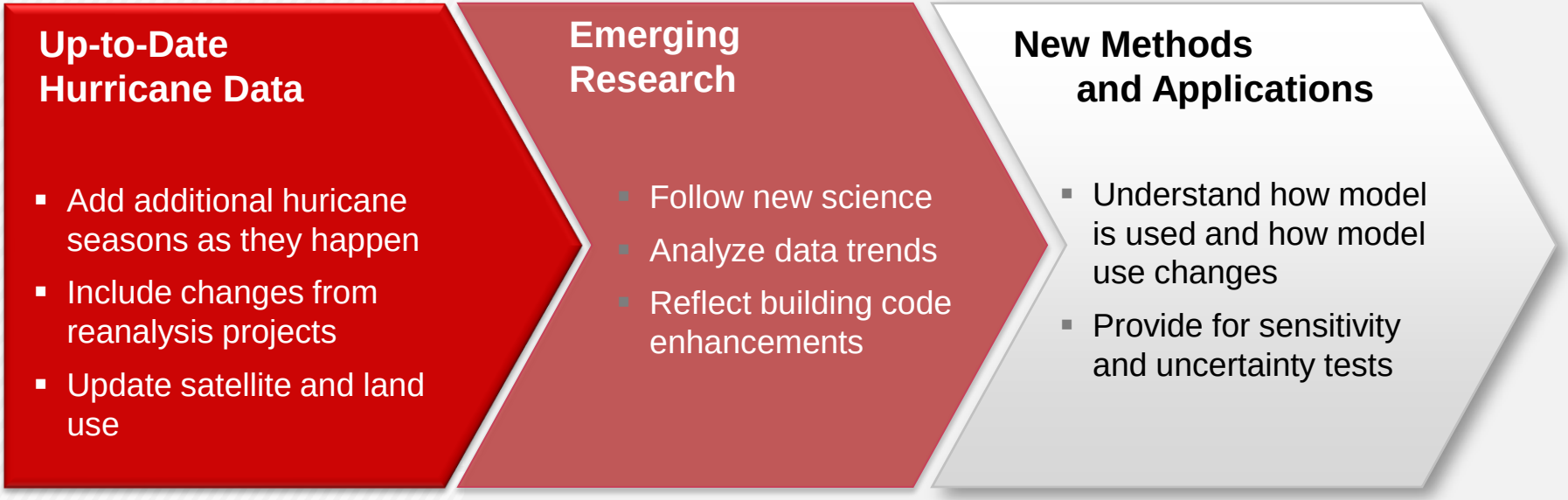
FINANCIAL MODELING: ALLOCATING LOSS

- Loss for a given event is borne by multiple participants
- Variability around mean drives potential loss to higher layers
- Exceedance probability curves can be generated for each participant



FUTURE WORK


Up-to-Date Hurricane Data
Add additional huricane seasons as they happen
Include changes from reanalysis projects
Update satellite and land use
Emerging Research
Follow new science
Analyze data trends
Reflect building code enhancements
New Methods and Applications
Understand how model is used and how model use changes
Provide for sensitivity and uncertainty tests