INTRODUCTION TO CATASTROPHE MODELING

MODEL SPECIALIST TEAM

TWO-DAY INTRO TO CAT TRAINING: AGENDA

Core Concepts

- What is catastrophe modelling?
- Why do we use catastrophe models?

RMS Modeling Framework

- Catastrophe Modelling Framework
  - Stochastic Event Set
  - Geocoding Module
  - Hazard Module
  - Vulnerability Module
  - Financial Model

Financial Model Theory

- Context and core concepts
- Core financial model processes
- Defining and generating statistics

WHY CATASTROPHE MODELING?

Top 10 insured catastrophe losses (1970-2018)

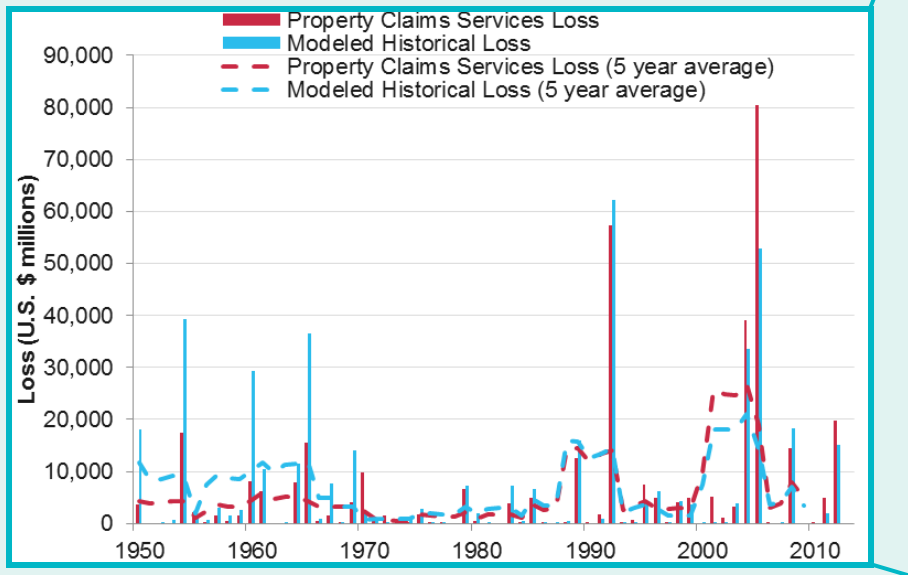
Date	Event	Affected Area	Insured Losses in US$ (bn)
August 2005	Hurricane Katrina	United States, Gulf of Mexico	82.4
March 2011	Tohoku Earthquake (Mw 9.0), plus tsunami	Japan	38.1
September 2017	Hurricane Maria	Caribbean	32
October 2012	Hurricane Sandy	U.S., Caribbean and Canada	30.8
September 2017	Hurricane Irma	U.S., Puerto Rico, U.S. Virgin Islands, Caribbean	30
August 2017	Hurricane Harvey	U.S.	30
August 1992	Hurricane Andrew	U.S., Bahamas	27.9
September 2001	Terror attacks on WTC, Pentagon and other buildings	U.S.	26
January 1994	Northridge earthquake (Mw 6.7)	U.S.	25.3
September 2008	Hurricane Ike	U.S., Caribbean and Gulf of Mexico	23.1

Source: Swiss Re, *sigma*, No. 1/2018

WHY NOT TAKE A TRADITIONAL APPROACH?

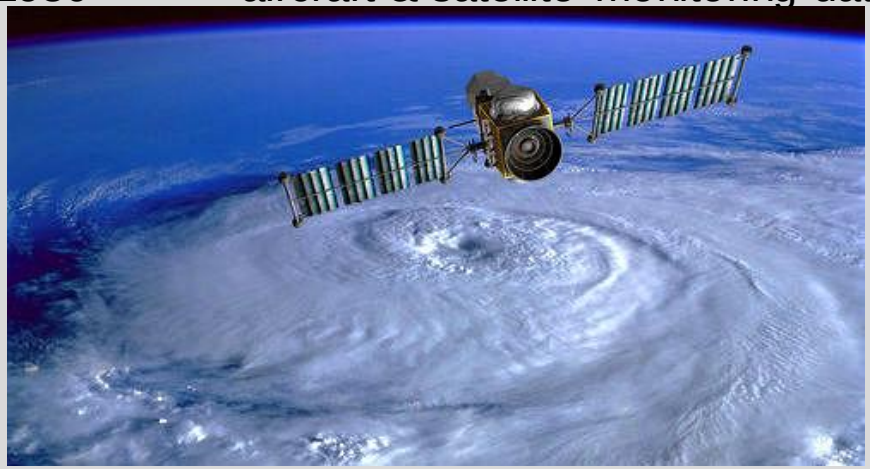
Traditional Approach

- Based on event history
- Difficult to compose a “complete” or even “sufficient” event history to develop a robust actuarial model



Historical US Hurricane Data

Pre-1900	anecdotal evidence and paleotempestology studies
1900	coastal population deemed sufficient to record all landfalls
~1950+	aircraft & satellite monitoring data



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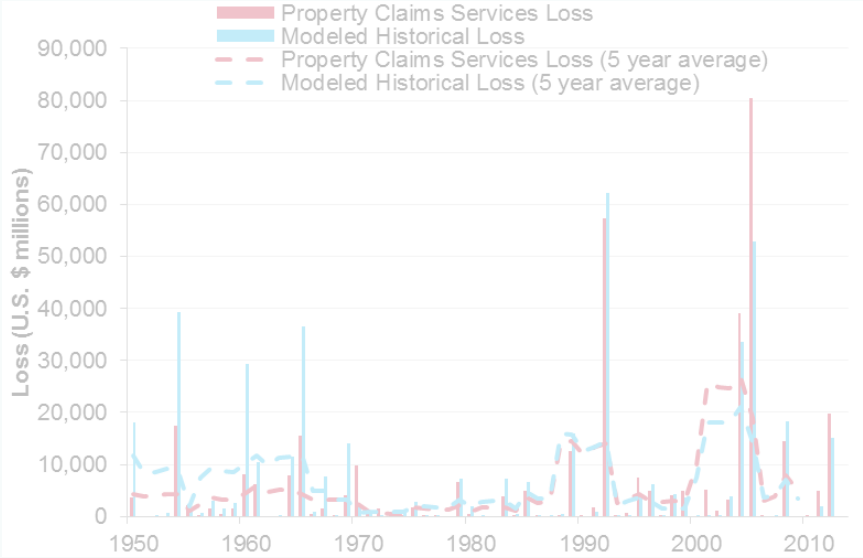
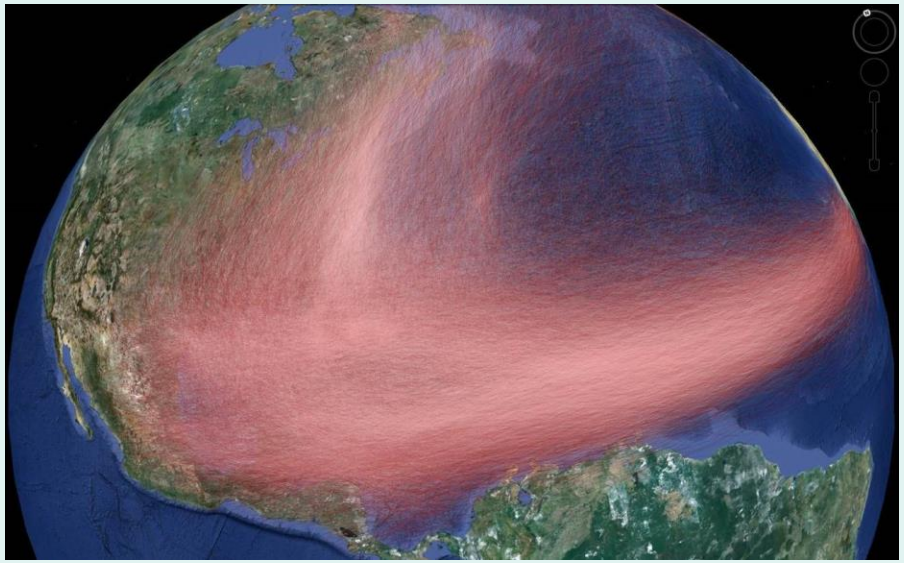
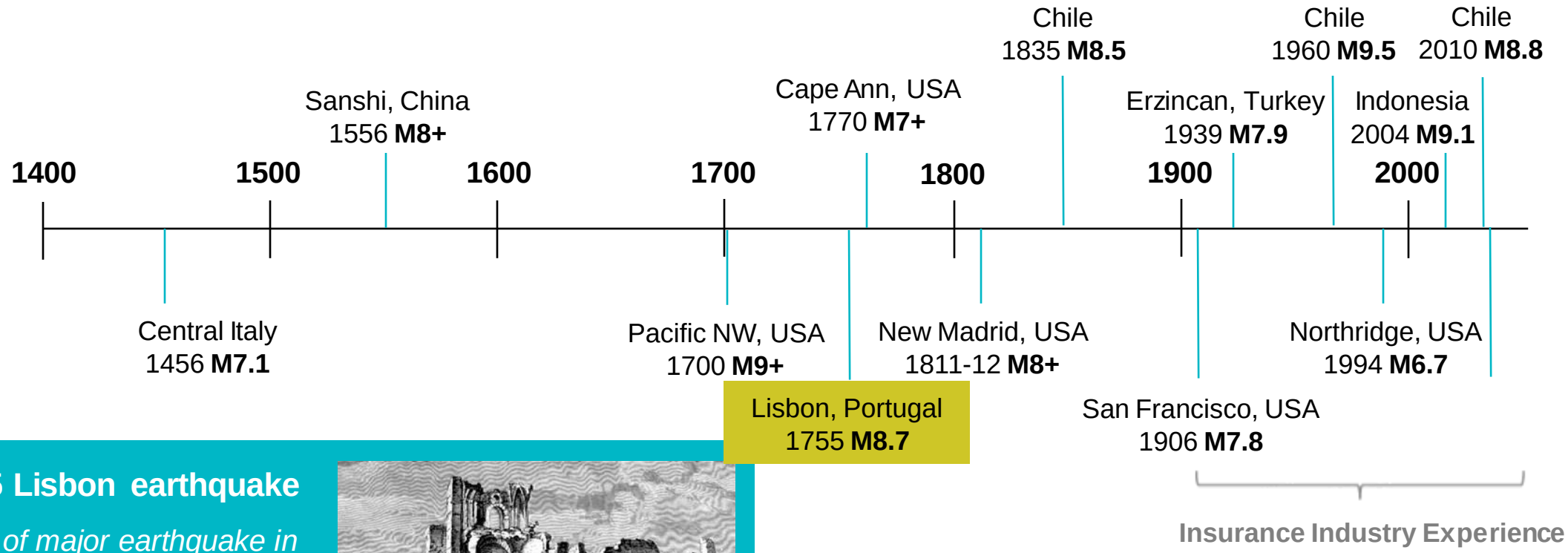


Catastrophe Modeling Approach

- Looks at all possible losses that extend beyond the historical record
- Based on what is plausible given current scientific understanding



LIMITED HISTORICAL EXPERIENCE: EARTHQUAKES



1755 Lisbon earthquake

Lack of major earthquake in Portugal since 1755

- *Long occurrence interval?*
- *Missing events?*

WHAT DOES RISK MODELER DO?

Exposure Management

- Exposures can be captured globally
- Can allow for expansion and diversification into new territories

Pricing

- Modelled output can be used as a guide for pricing risks

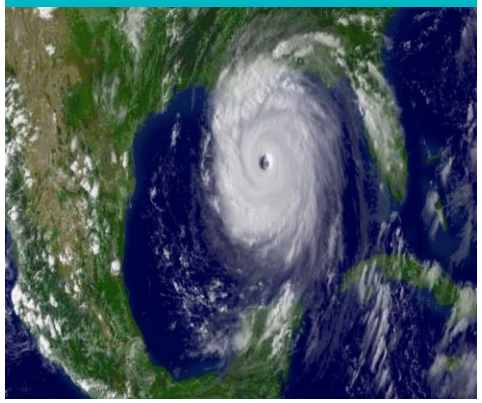
Capacity Management

- Clients must prepare for the occurrence of large events
- They must prove that they have sufficient capacity to pay out following such an event

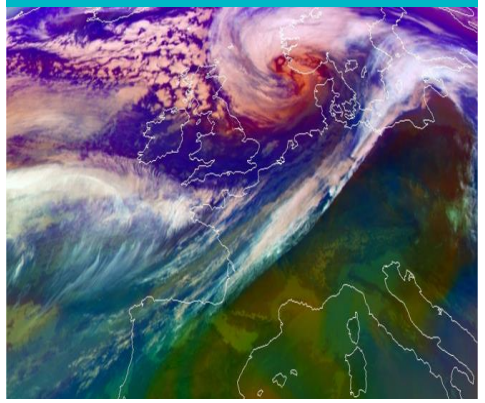
RMS MODELED PERILS

Earthquake

Tropical Cyclone



Extratropical Cyclone



Terrorism

Cyber

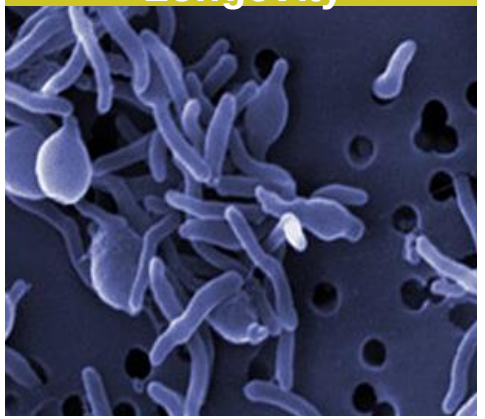
Flood

Winter Storm

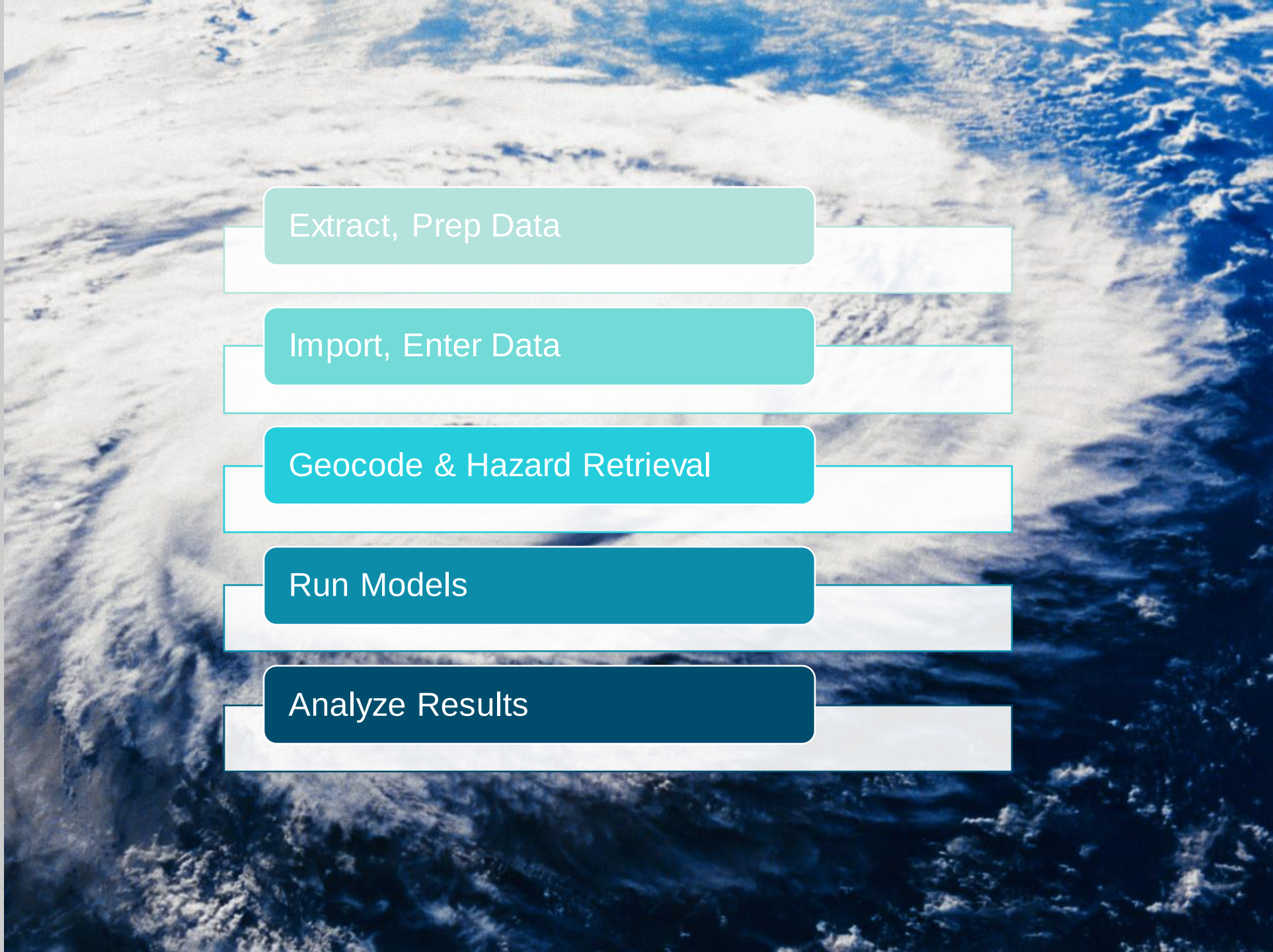
Wildfire

Severe Convective Storm

Pandemic & Longevity



CAT MODELING PROCESS

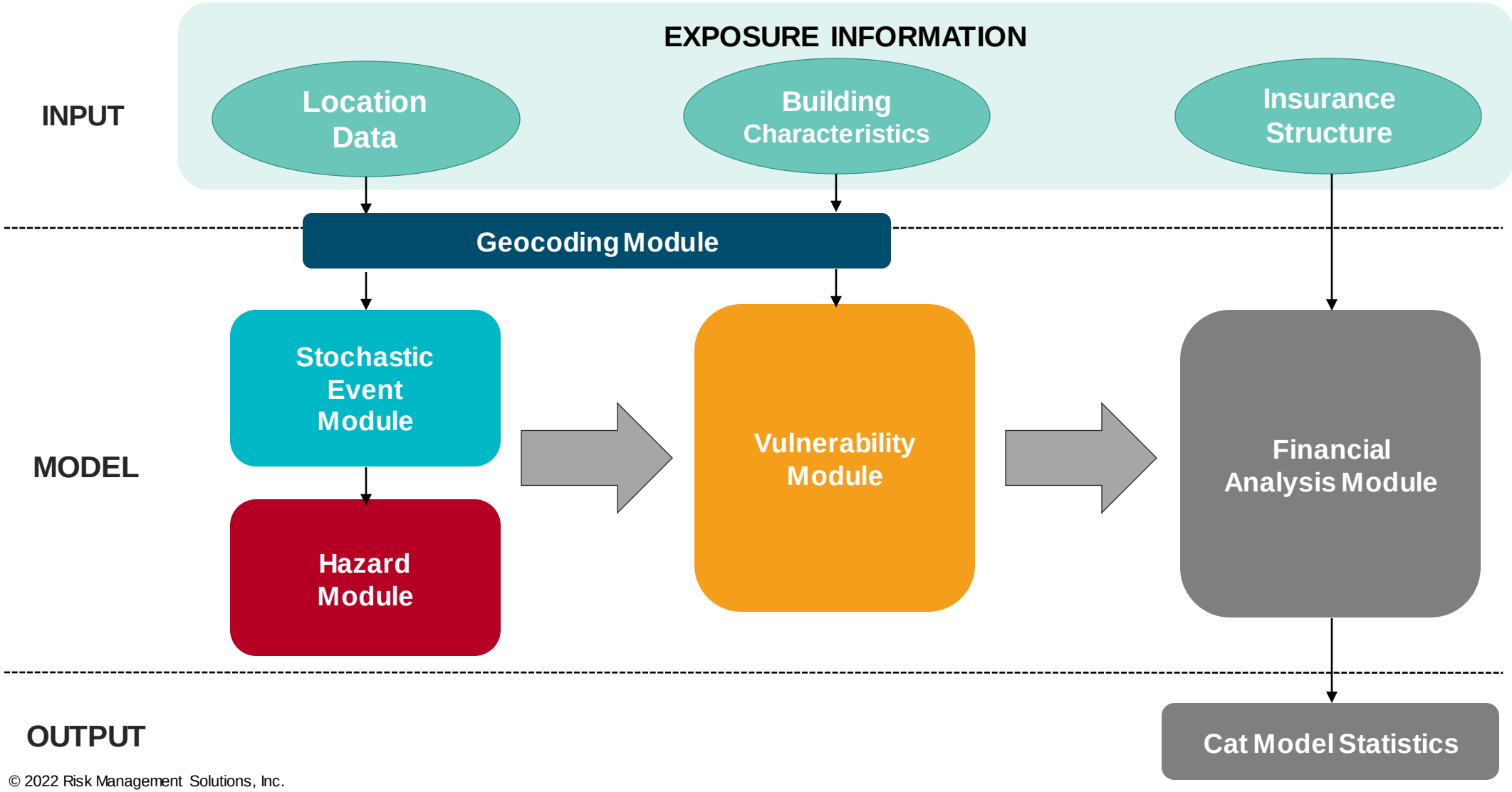


THE CATASTROPHE MODELING FRAMEWORK

CATASTROPHE MODELING FRAMEWORK

DEFINE PERIL	APPLY EXPOSURE	ASSESS HAZARD	CALCULATE DAMAGE	QUANTIFY LOSS
				
STOCHASTIC EVENT MODULE	GEOCODING MODULE	HAZARD MODULE	VULNERABILITY MODULE	FINANCIAL MODULE

WHERE DOES EXPOSURE INFORMATION FIT IN?



STOCHASTIC EVENT MODULE

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DEFINE PERIL	APPLY EXPOSURE	ASSESS HAZARD	CALCULATE DAMAGE	QUANTIFY LOSS
				
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What does stochastic mean?

Stochastic - having a random probability distribution or pattern that may be analysed statistically but may not be predicted precisely.

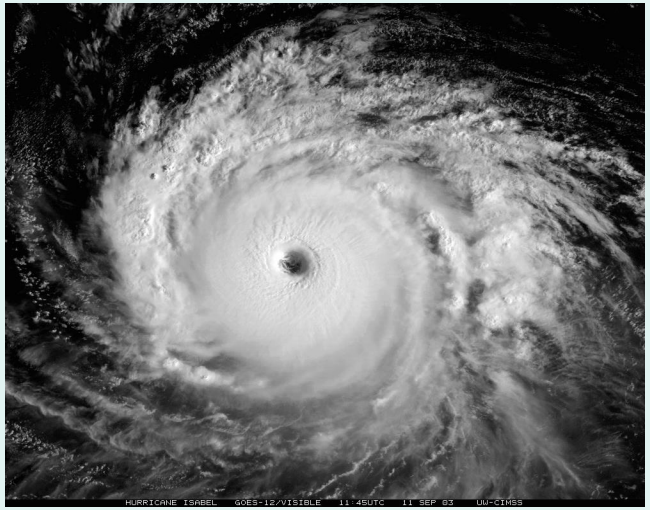
Stochastic Process - In probability theory and related fields, a **stochastic** or random process is a mathematical object usually defined as a collection of random variables.

What do we mean by this? - A scientific representation of all plausible events relevant to (re)insurance industry losses.

DEFINING THE PERIL: WINDSTORM

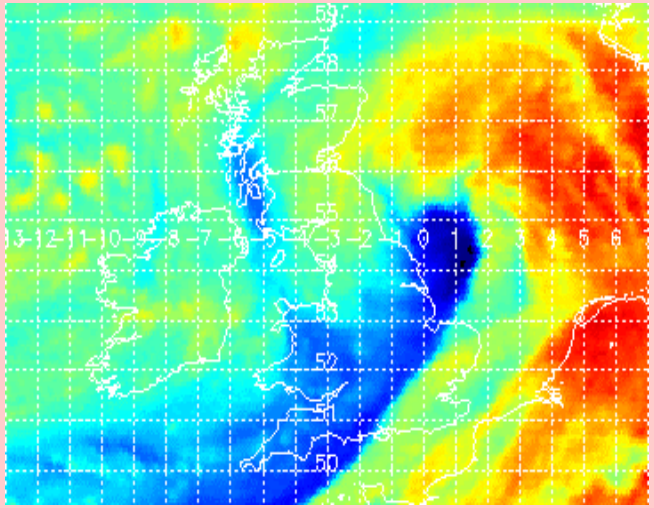
Tropical Cyclone

- Hurricanes
- Typhoons
- Cyclones



Extratropical Cyclone

- Occur in middle hemispherical latitudes
- e.g. European windstorm

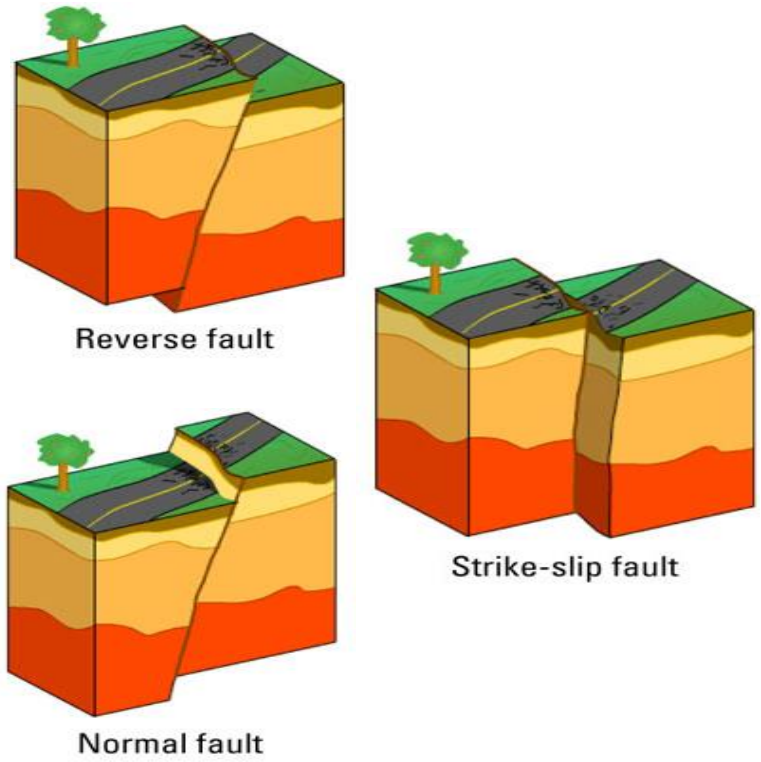


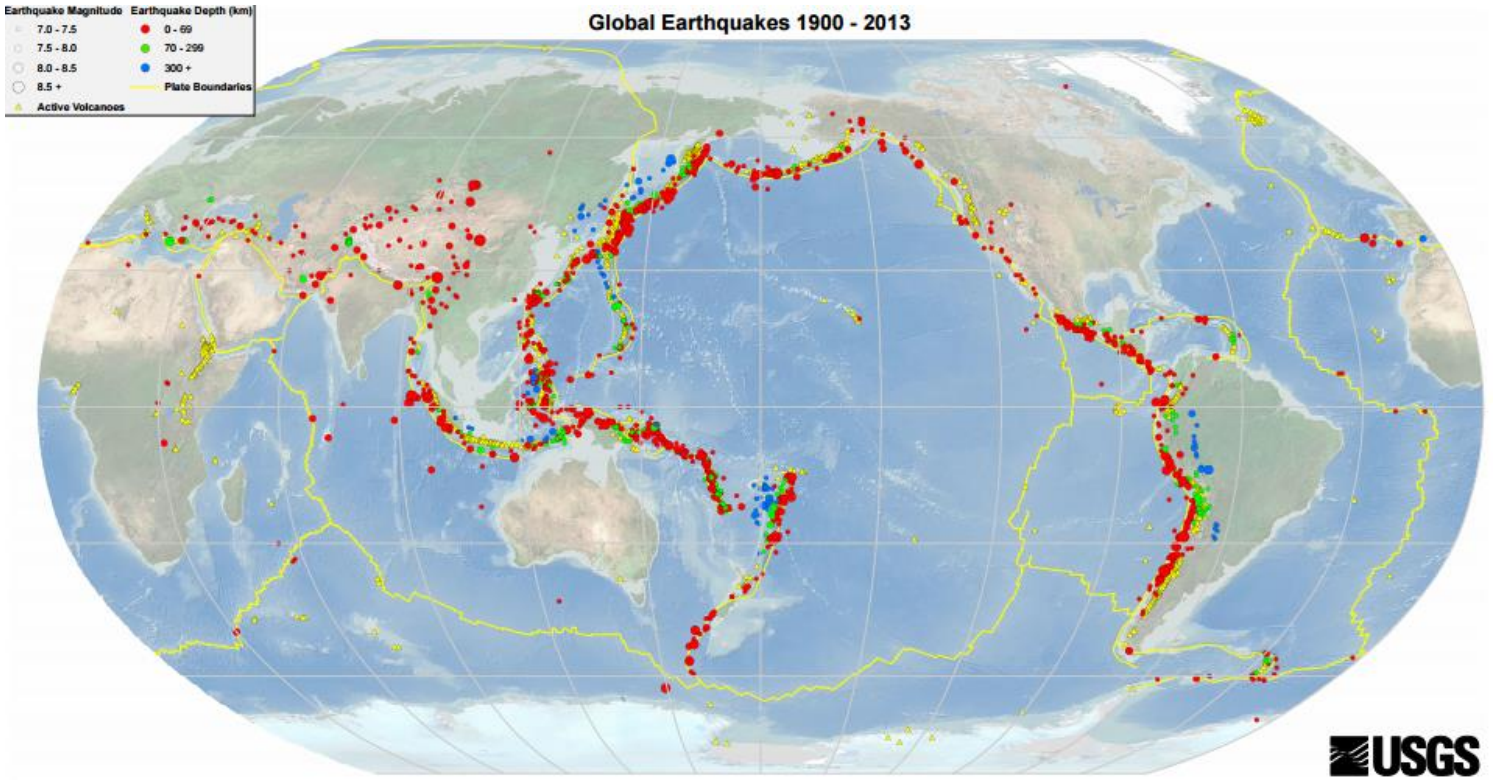
Severe Convective Storm

- Hail
- Straight-line wind
- Tornado

DEFINING THE PERIL: EARTHQUAKE

*An **earthquake** is a term used to describe the **sudden slip on a fault**, and the resulting **ground shaking** and radiated seismic energy caused by the slip*





DEFINING THE PERIL: FLOOD

Flood - to cover or submerge (an area) with water.

Riverine/ Fluvial Risk

Major rivers overtopping or breaching their banks and flooding surrounding area

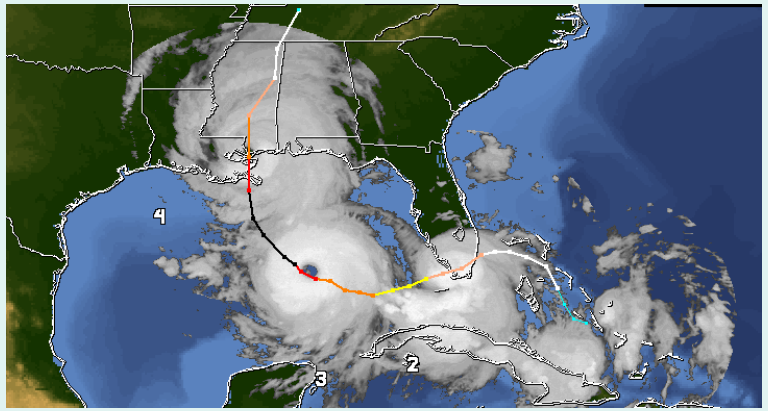
Pluvial Risk

Excess heavy rainfall causes a flood event independent of an overflowing water body or major floodplain (includes minor rivers/streams)

KEY EVENT PARAMETERS

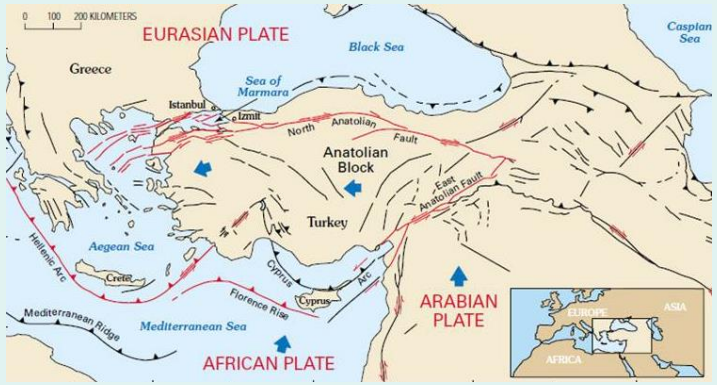
Tropical Cyclone

- Track
- Intensity
  - *Minimum central pressure*
  - *Maximum winds*
  - *Storm Category*
- Rate



Earthquake

- Seismic Sources
  - *Crustal (faults, background)*
  - *Subduction (interface, interslab)*
- Fault Rupture Length
- Maximum Magnitude
- Rate



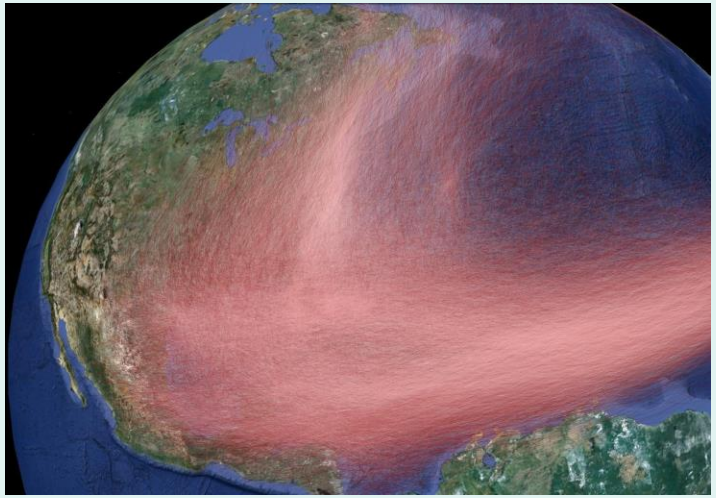
Flood

- Antecedent conditions
- Rainfall
- Major and Minor River network
- Inundation Depth
  - Fluvial and Pluvial

CREATING AN EVENT SET

Tropical Cyclone

- Probabilistic modelling based on:
  - Historical event analysis
  - Environmental and geophysical properties
- Events set by peril-region

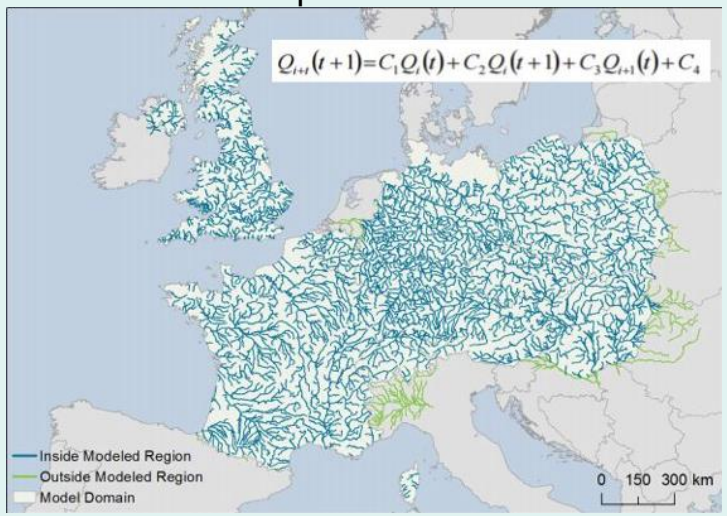


Earthquake

- Model known faults
- Capture all other possible earthquakes through background seismicity
- Probabilistic modelling based on:
  - Historical event analysis
  - Completeness considerations
  - Maximum magnitude consideration

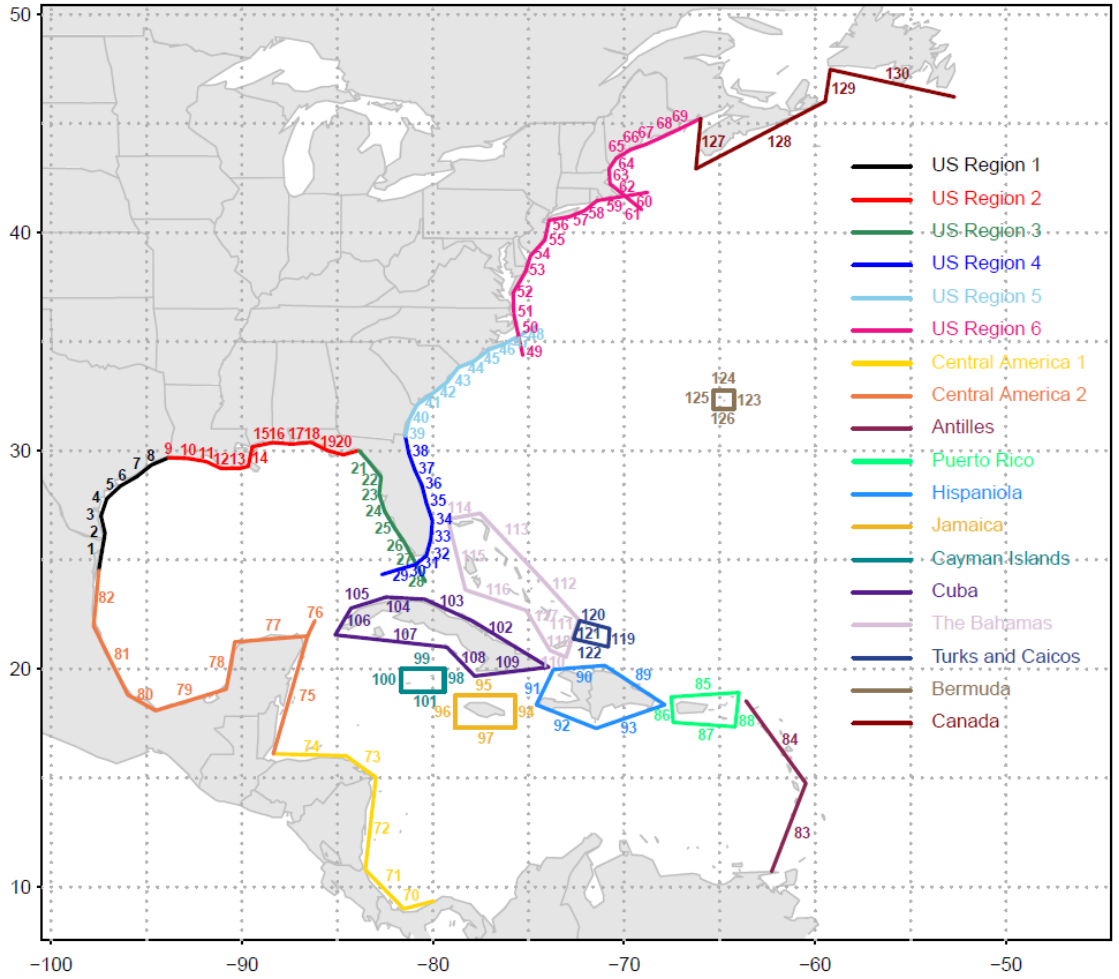
Flood

- Probabilistic modelling based on:
  - Observed rainfall patterns which are simulated over long timeframes to account for extreme events
  - Modelling the full hydrological cycle
  - Precipitation and rivers outside the model domain are considered for all water input



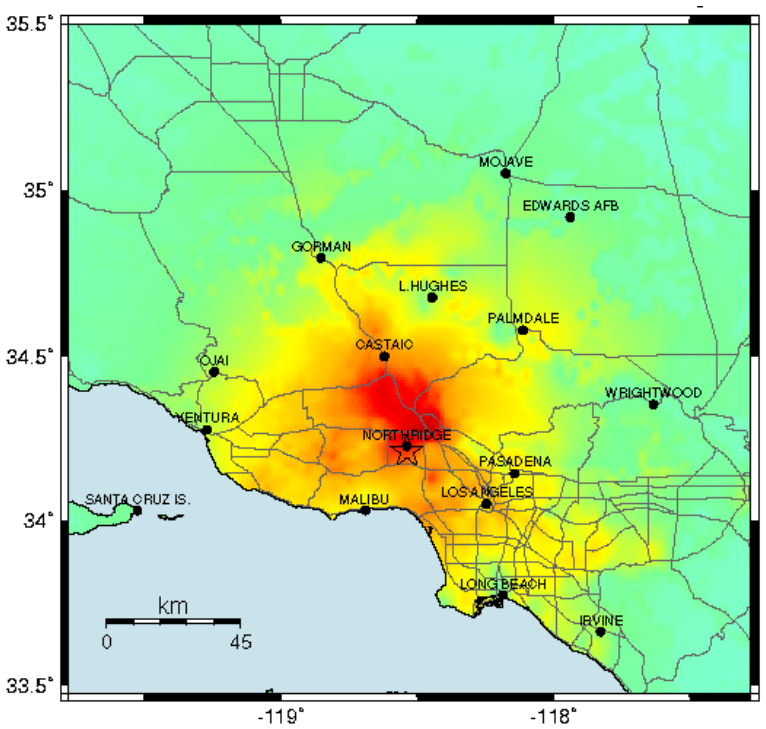
STOCHASTIC EVENT RATES

- A single event's *expected* rate of occurrence over the course of one year
  - *e.g. an rate of 0.5 implies an event is **expected** to occur every two years (**return period**) over the long term*
  - *If this event does not occur in a year, it is **not guaranteed** to occur the next year*
- Derived from historical analysis, peer-reviewed studies, statistical and computer analysis, expert judgment
- Critical in capturing key financial metrics

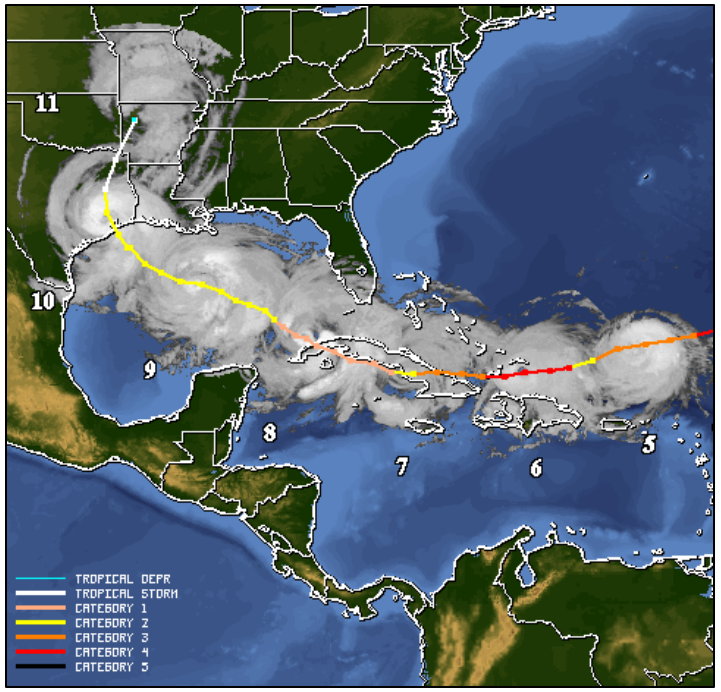


Event rates by gate in the North Atlantic Hurricane Model

HISTORICAL EVENTS



Northridge EQ (Mw6.7), 1994



Hurricane Katrina, 2005

Superstorm Sandy, 2012

Users can also run scenarios based on significant historical events

GEOCODING MODULE

GEOCODING MODULE

DEFINE PERIL	APPLY EXPOSURE	ASSESS HAZARD	CALCULATE DAMAGE	QUANTIFY LOSS
				
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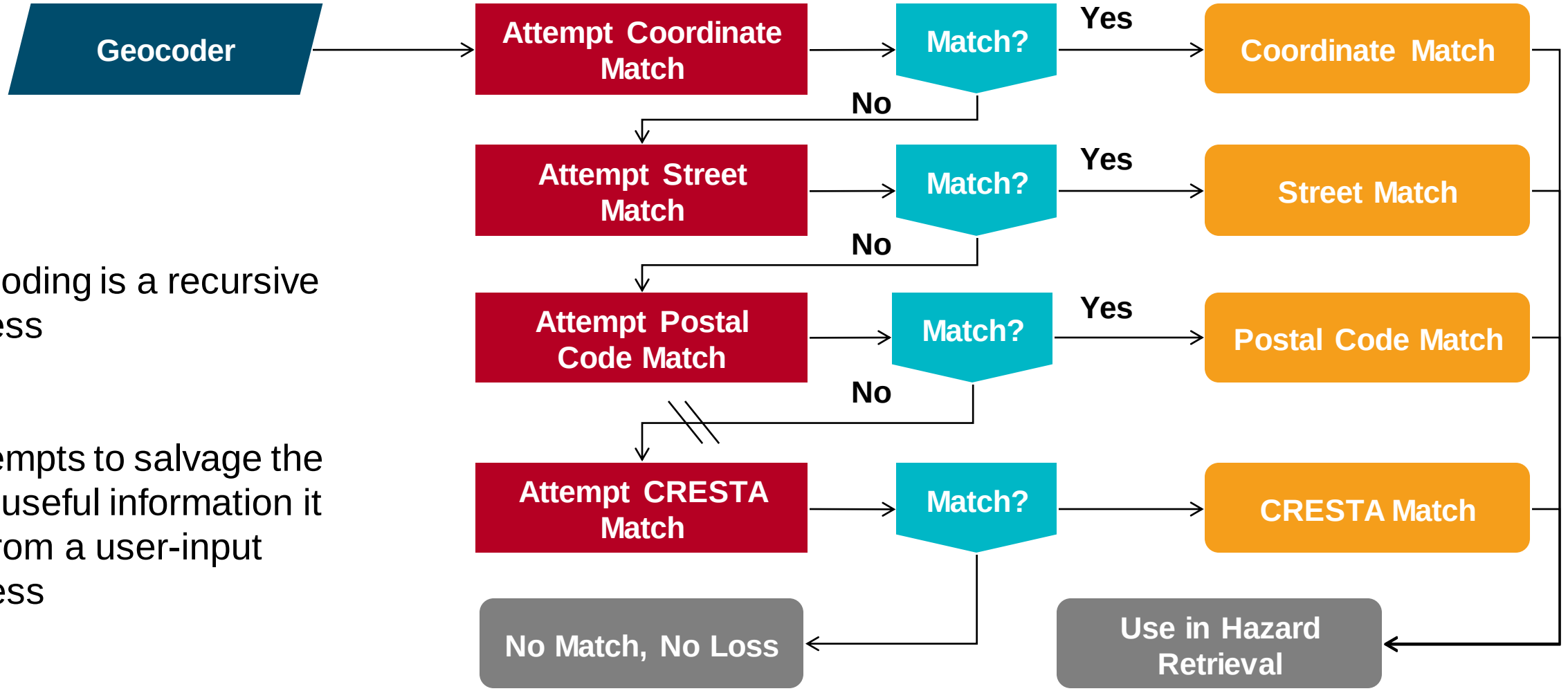
What is Geocoding?

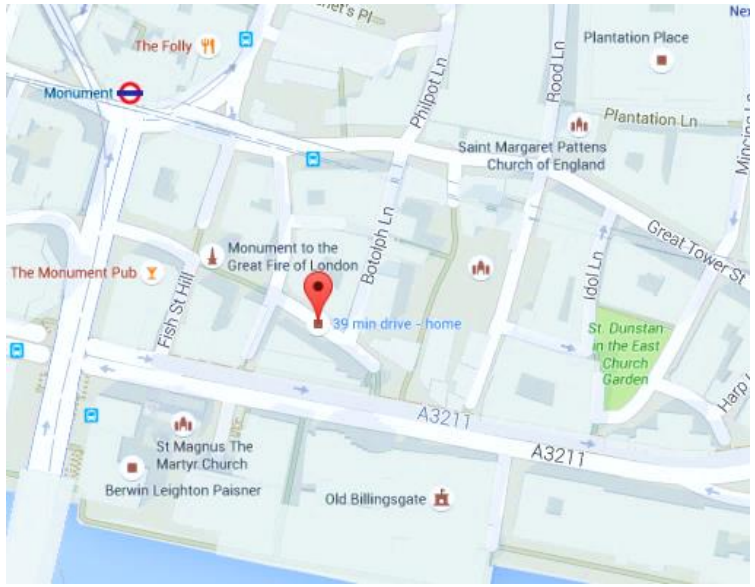
Geocoding is the translation of **local address data** into **global coordinates**

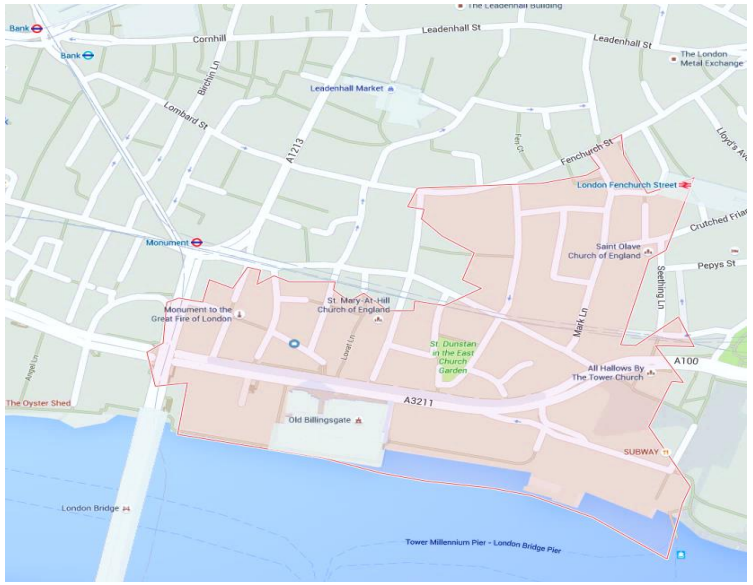
Geocoding Process

- Geocoding is a recursive process
- It attempts to salvage the most useful information it can from a user-input address



Geocoding Principles





Street Address/ Building	Postcode Sector	City

Decreasing Precision = Increasing Uncertainty

Geocoding Resolutions

Resolution	Description
1	Coordinate
2	Street Address/ Building/ Parcel
3	High Resolution Postcode/ Block
4	Street Name
5	Postcode
6	Neighbourhood
7	City
8	Admin3 (District)
9	Admin2 (County)
10	Admin1 (State)
11	CRESTA

Recommended minimum resolutions:

High hazard gradient perils…

- Earthquake
- Flood
- Storm surge
- Hurricane
- Terrorism

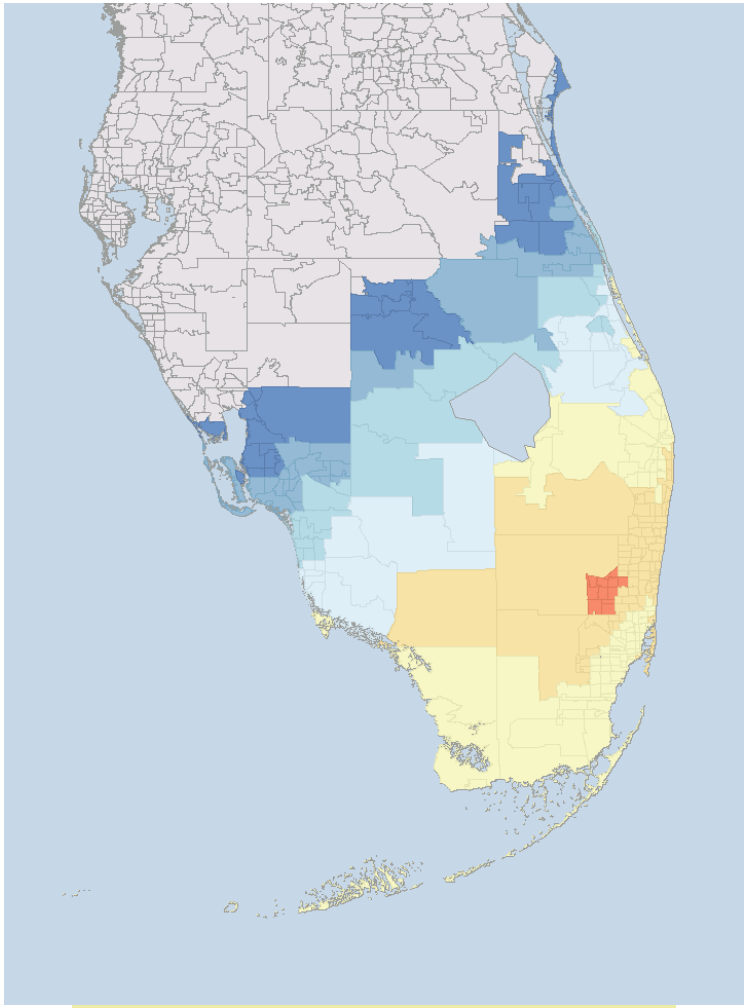
…High resolution (1,2,3)

Lower hazard gradient perils…

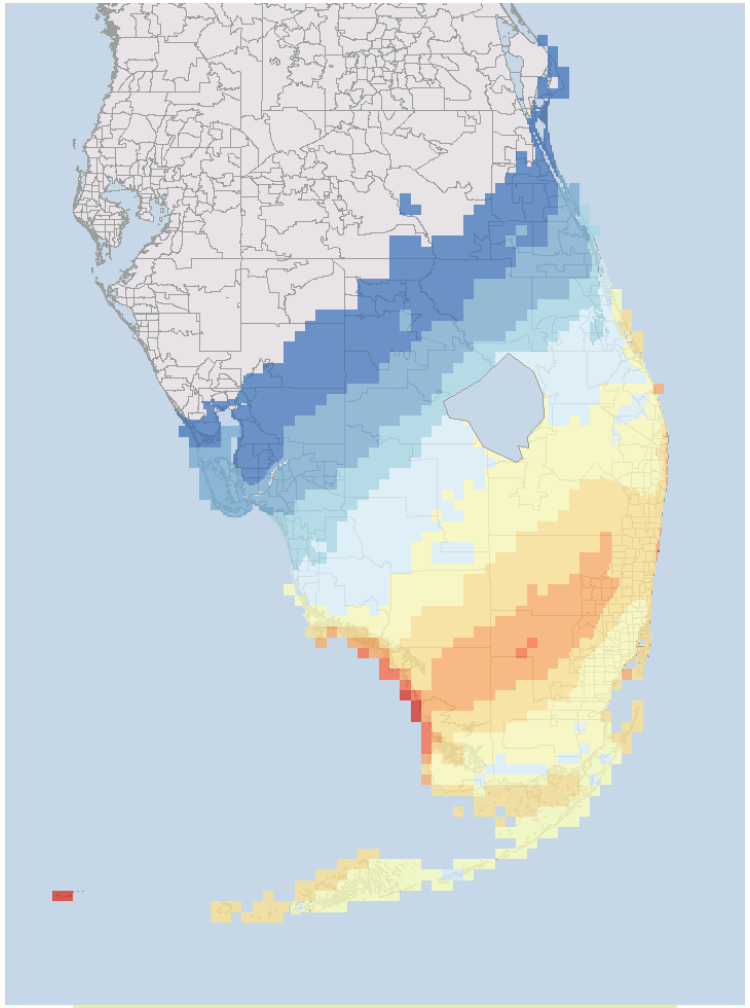
- European windstorm
- Typhoon

…Postcode (5)

Importance of Geocoding: Hurricane Wilma (2005)



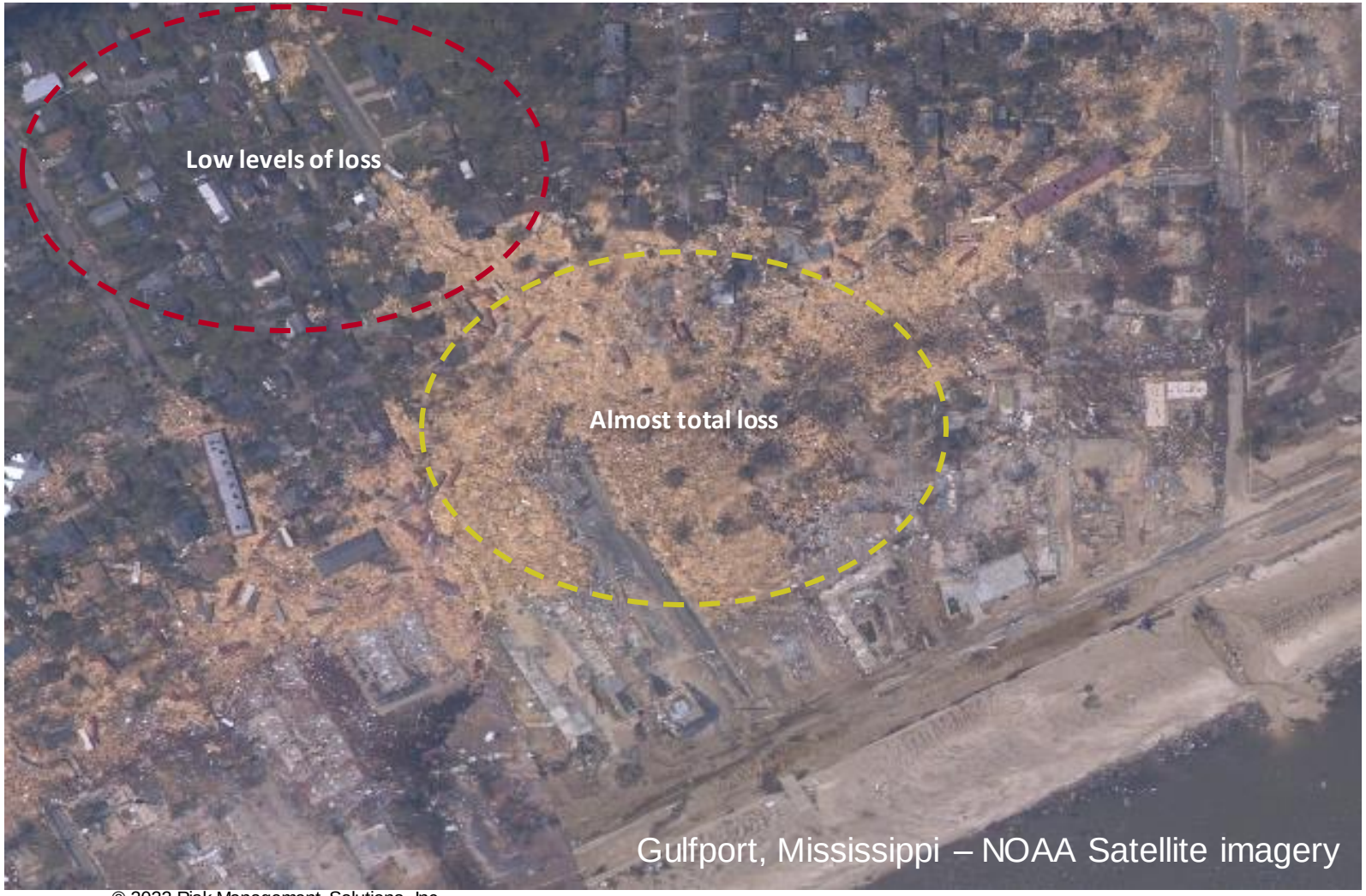
Postal code geohaz



Hi-res geohaz

What is the potential impact of having low resolution data?

Importance of Geocoding: Hurricane Katrina



High quality, high resolution location data leads to better loss estimates

Summary

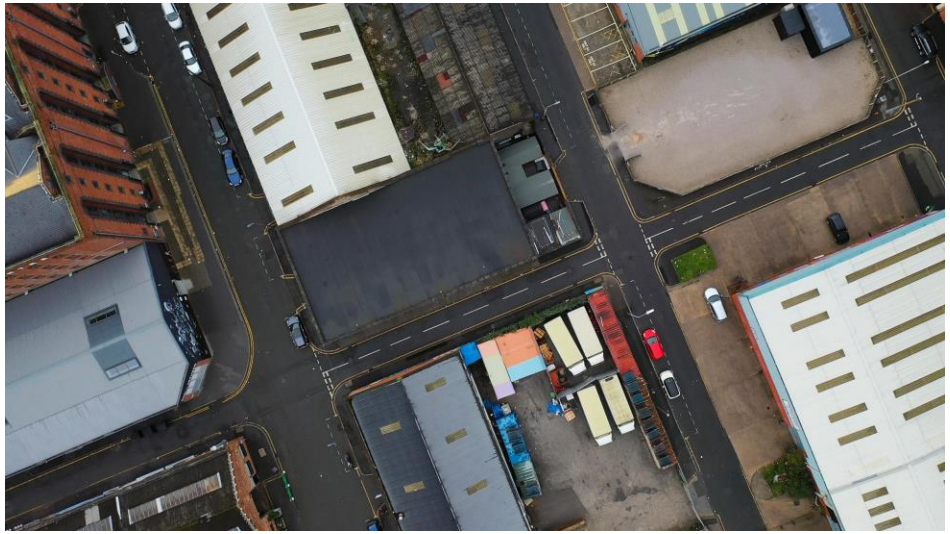
- Always aim to record highest detail
  - Accumulation management
  - Model resolution increases over time

- Variations by Country and Peril
  - Relevant address information
  - Underlying hazard and model resolution

Campus functionality

Modelling Multi-Building Locations

- Allows you to split value into several locations across a site
- Applies a correlation to the campus locations to account for similar hazard levels between buildings
- Example use case: Industrial Facilities



See Modelling Multi-Building Locations document

HAZARD MODULE

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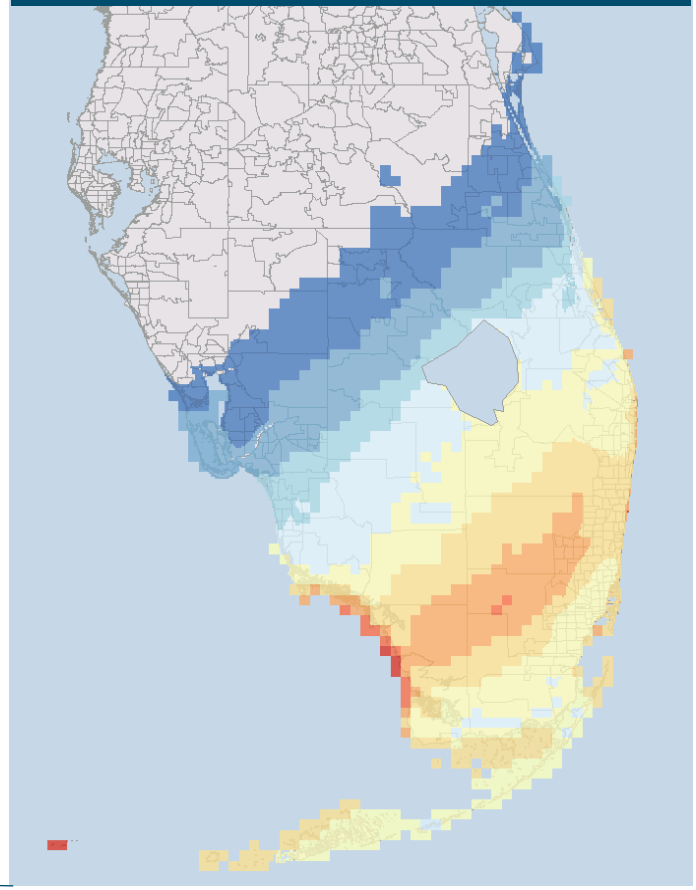
WHAT DOES THE HAZARD MODULE DO?

Ultimate aim: Return hazard parameter(s) applicable to building damage at a location

Windstorm

Maximum peak wind gust

Peak Gust Footprint



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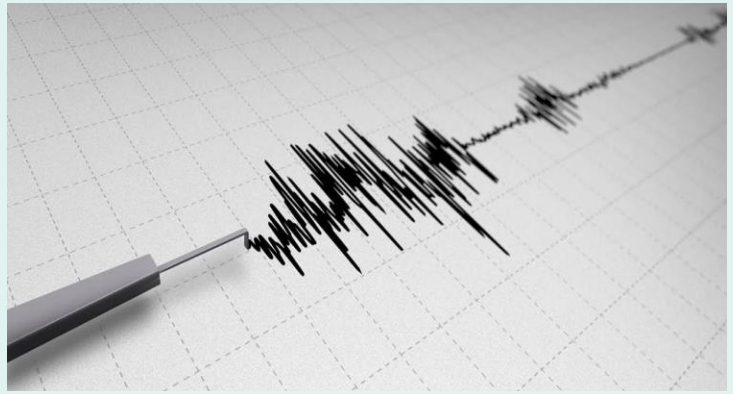
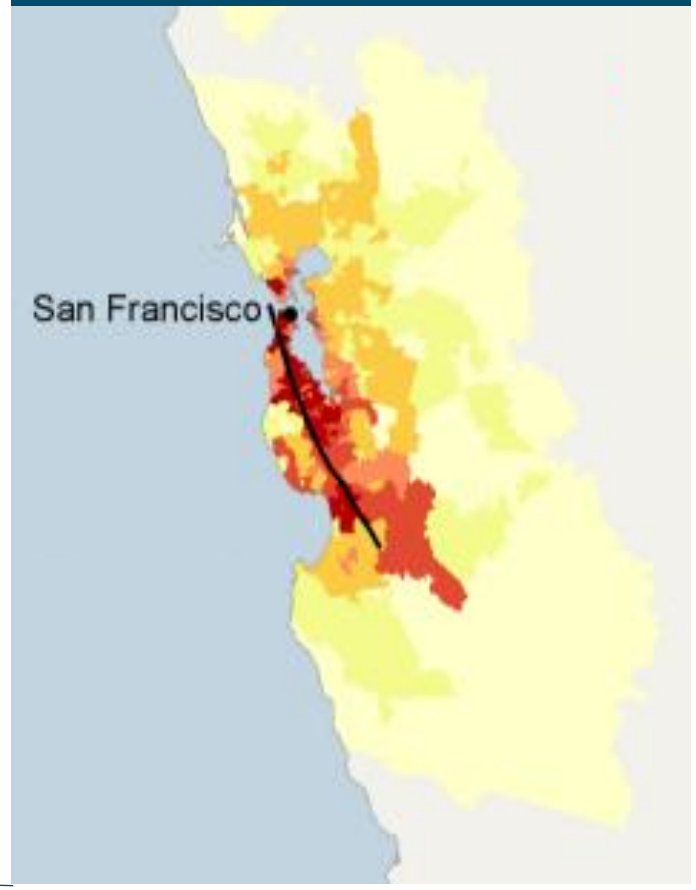
Earthquake



Ground Shaking Intensity

Ground Shake Footprint



HAZARD MODULE: KEY PROCESSES

1. Local Hazard Identification

- Local site conditions that can affect susceptibility to damage are considered

2. Location Event Modelling

- Key hazard parameters for each stochastic event at each location are returned

Key hazard parameter

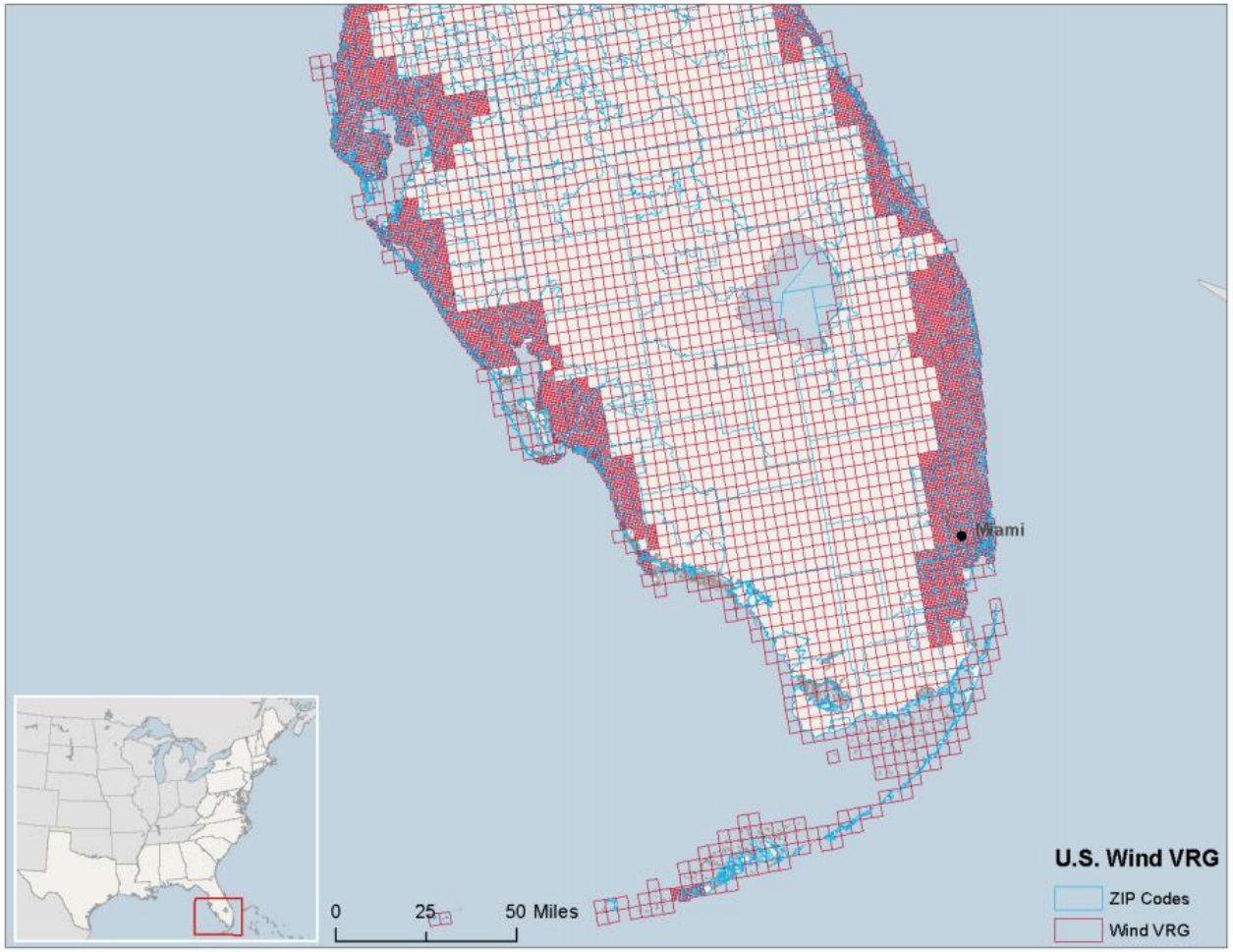
- Both of these processes can inform the model of the key hazard parameter

Geocoding Impact

Hazard cannot be retrieved at a higher resolution than the geocoding match level

VARIABLE RESOLUTION GRID (VRG)

- Grid size dependent upon:
  - Hazard gradient
  - Exposure / population density
- Cells vary in size (seven sizes) :
  - minimum = 0.0005 degree (~50m)
  - maximum = 1 degree (~100km)
- Not constrained by geographic boundaries



Thinking about specific locations – what can you think of that may impact hurricane hazard?

HAZARD MODULE: KEY PROCESSES (WINDSTORM)

1. Local Hazard Identification

- Local site conditions that can affect susceptibility to damage are considered

2. Location Event Modelling

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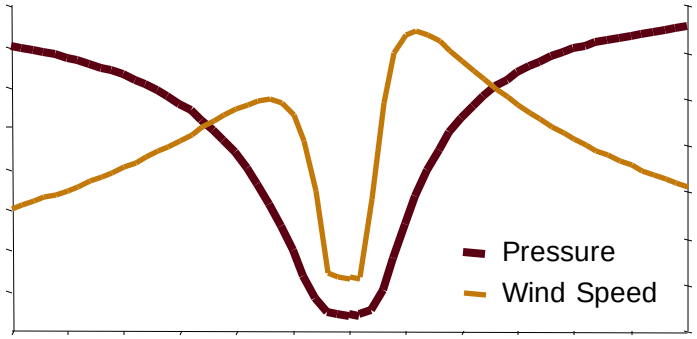
Process for a single event



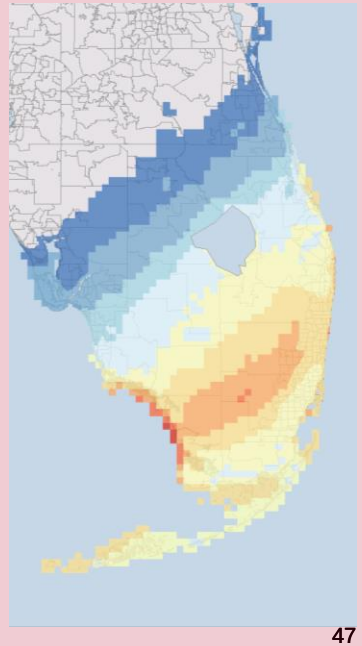
Take idealized wind field at each point along storm track

Surface Roughness

- 10 roughness categories
- Impacts peak wind speed

Site-level hazard

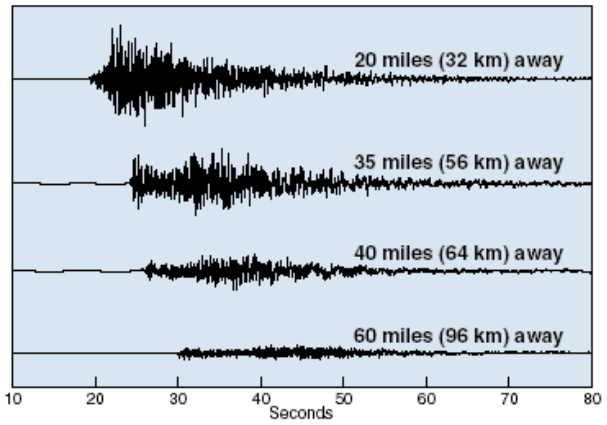
- Conversion of wind speed to peak gust
- Peak gust stored at VRG level



Can you think of any site specific examples for earthquake?

HAZARD MODULE: KEY PROCESSES (EARTHQUAKE)

Process for a single event



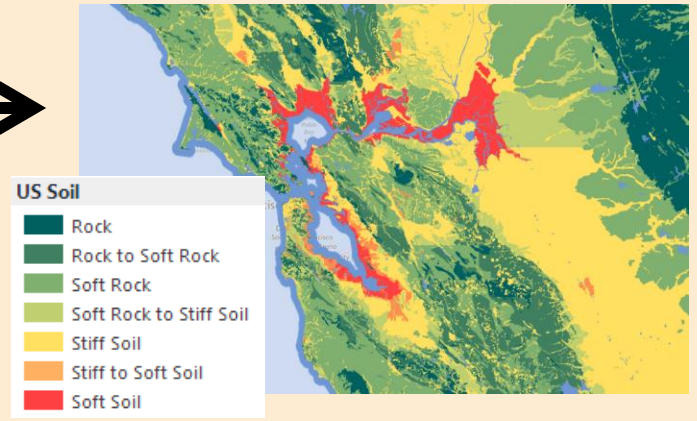
Determine ground motion attenuation with distance from fault

1. Local Hazard Identification

- Local site conditions that can affect susceptibility to damage are considered

Soil Type

- Surficial geology determines how ground shaking will be amplified at a site



2. Location Event Modelling

- Key hazard parameters for each stochastic event at each location are returned

Site-level hazard

- Output ground shaking at site

SECONDARY PERILS: LIQUEFACTION & LANDSLIDE

- **Liquefaction** and **landslide** can increase damage ratio at a site

Liquefaction in Duzce EQ, Turkey (1999)

SECONDARY PERILS: LIQUEFACTION & LANDSLIDE

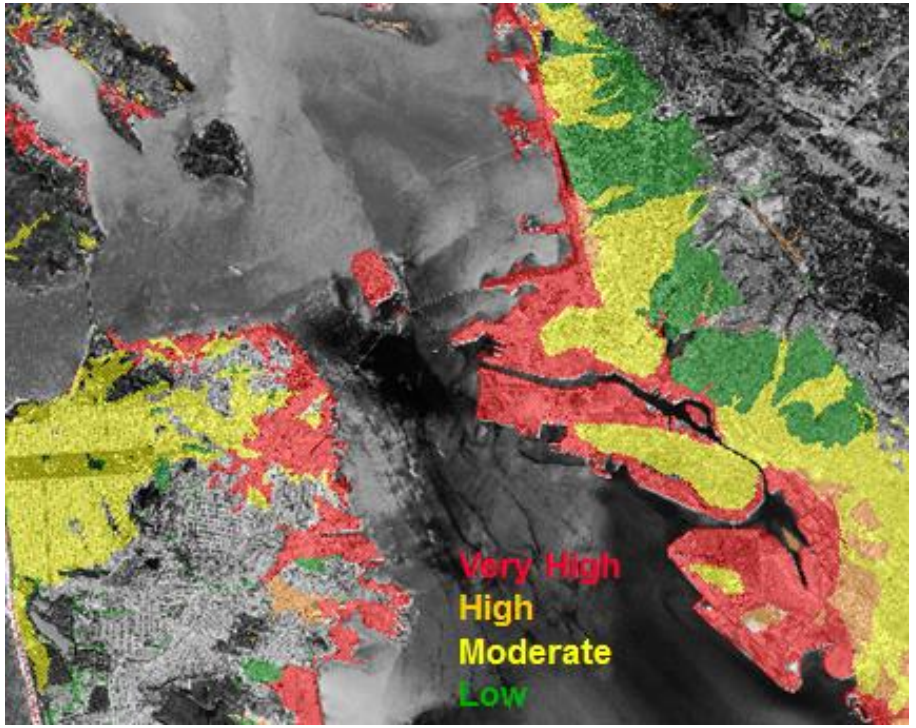
- **Liquefaction** and **landslide** can increase damage ratio at a site

- Doesn't alter the ground shaking, but adds a separate component of damage

Landslide in San Salvador EQ, El Salvador (2001)

SECONDARY PERILS: LIQUEFACTION & LANDSLIDE

- **Liquefaction** and **landslide** can increase damage ratio at a site
- Doesn't alter the ground shaking, but adds a separate component of damage
- Damage based on site's susceptibility to sub-peril plus ground shaking intensity



Liquefaction susceptibility data for San Francisco & Oakland

SUB-PERILS

Storm Surge

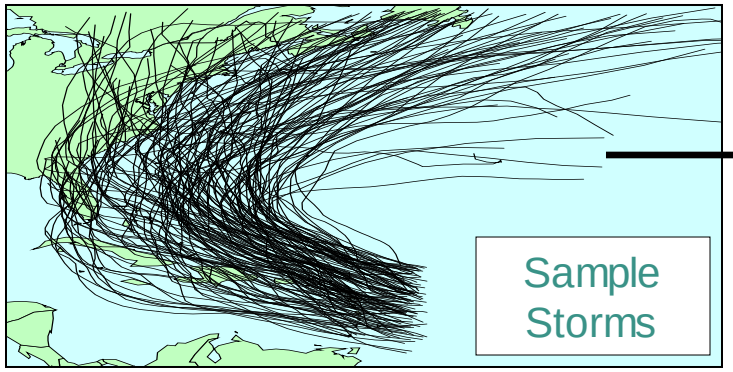
Fire Following Earthquake

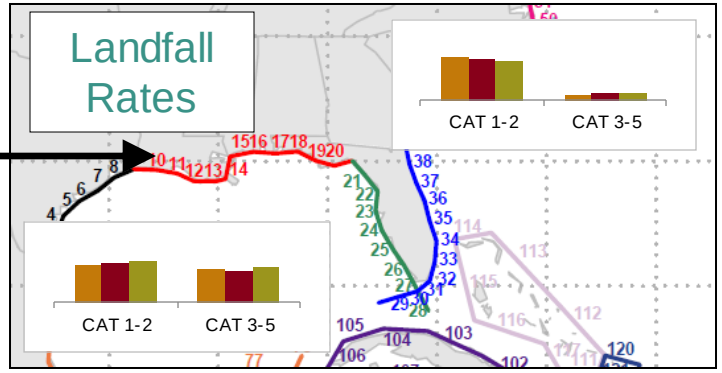
Sprinkler Leakage

Tsunami

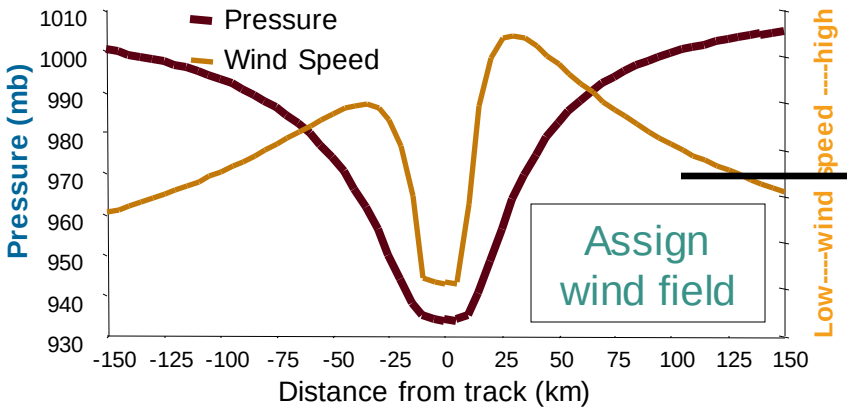
GENERATING STOCHASTIC WIND FIELDS

Event Set Generation:

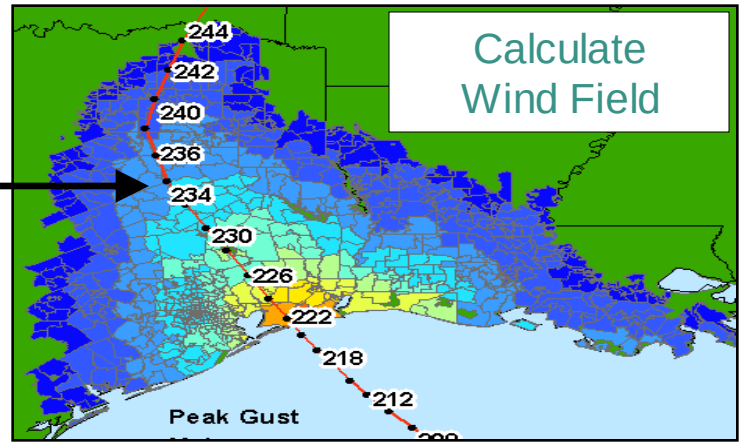




Hazard:



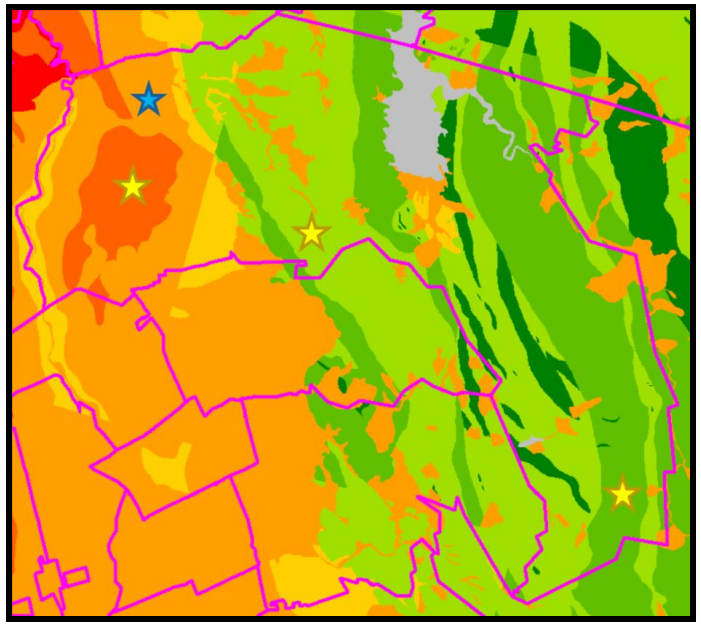
Calculate Surface Roughness

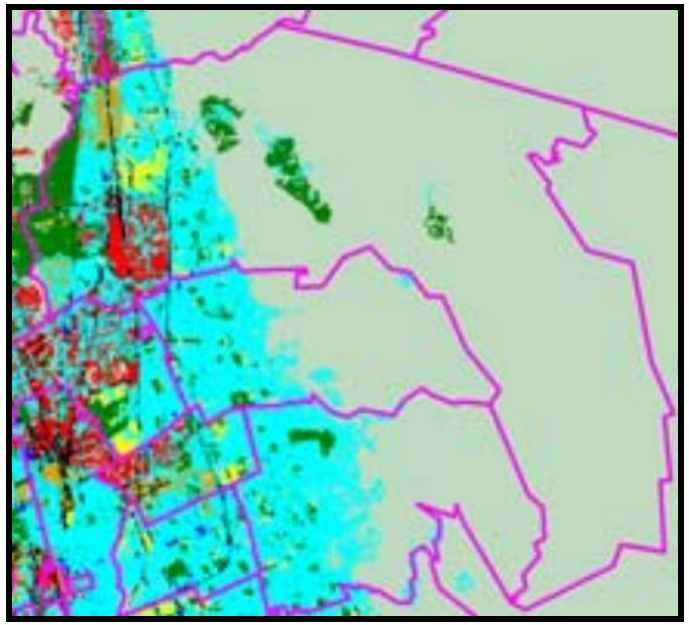


What if we have low geocoding resolution?

Aggregate hazard

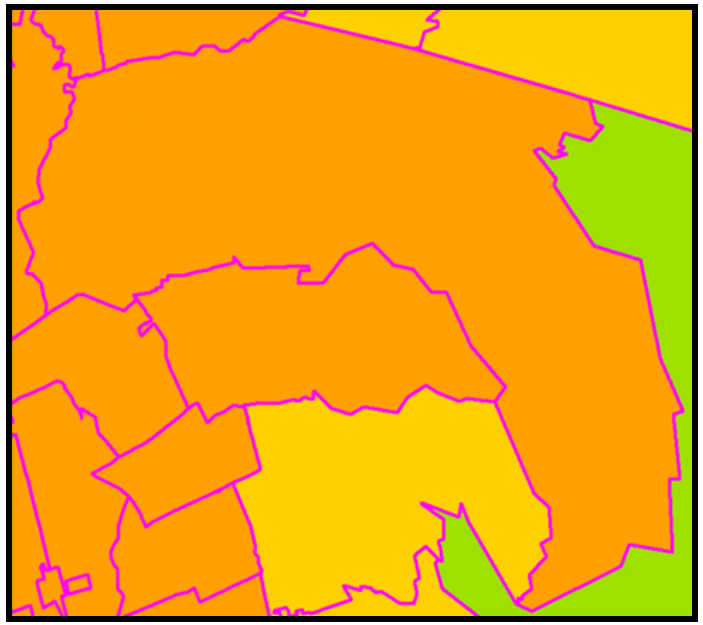
- How does Risk Modeler (non-HD) deal with assigning hazard to aggregate locations – i.e. those that do not return a coordinate during the geocoding process?





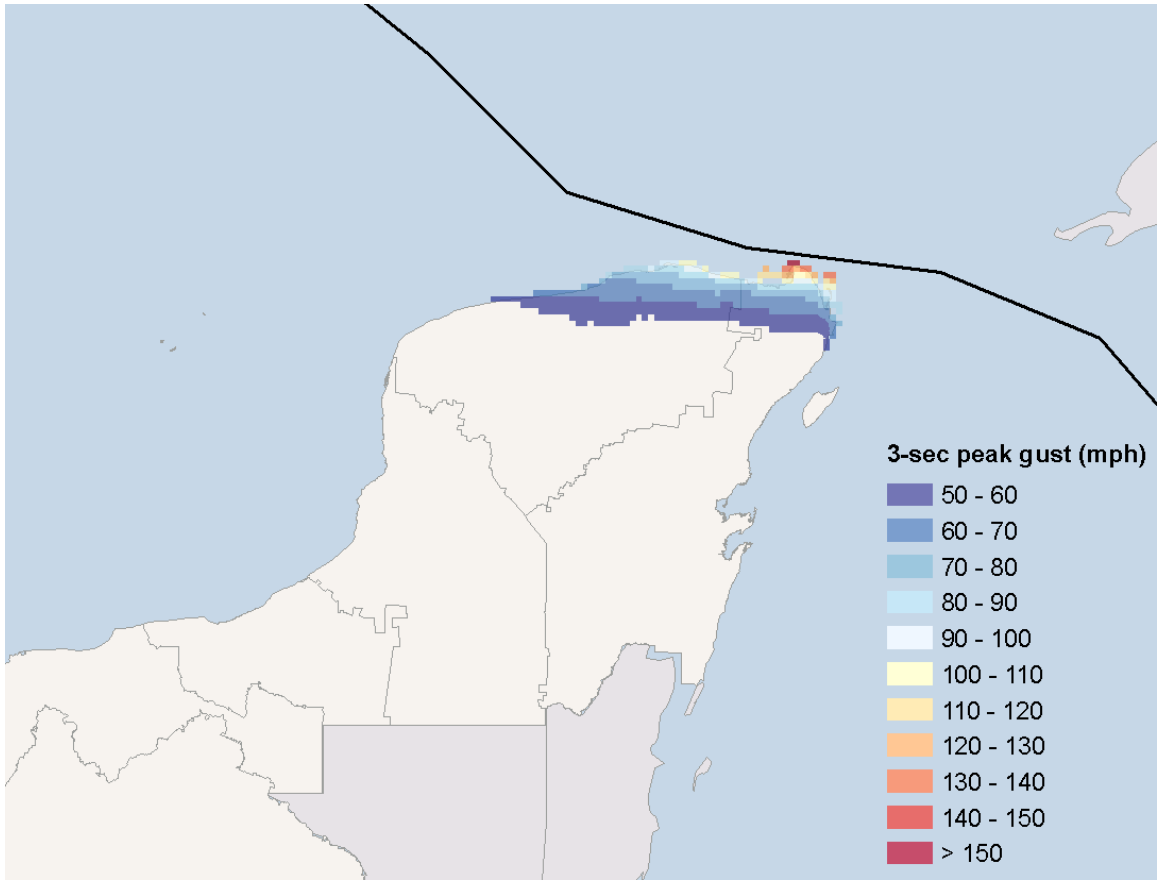
Aggregate hazard

- How does Risk Modeler (non-HD) deal with assigning hazard to aggregate locations – i.e. those that do not return a coordinate during the geocoding process?

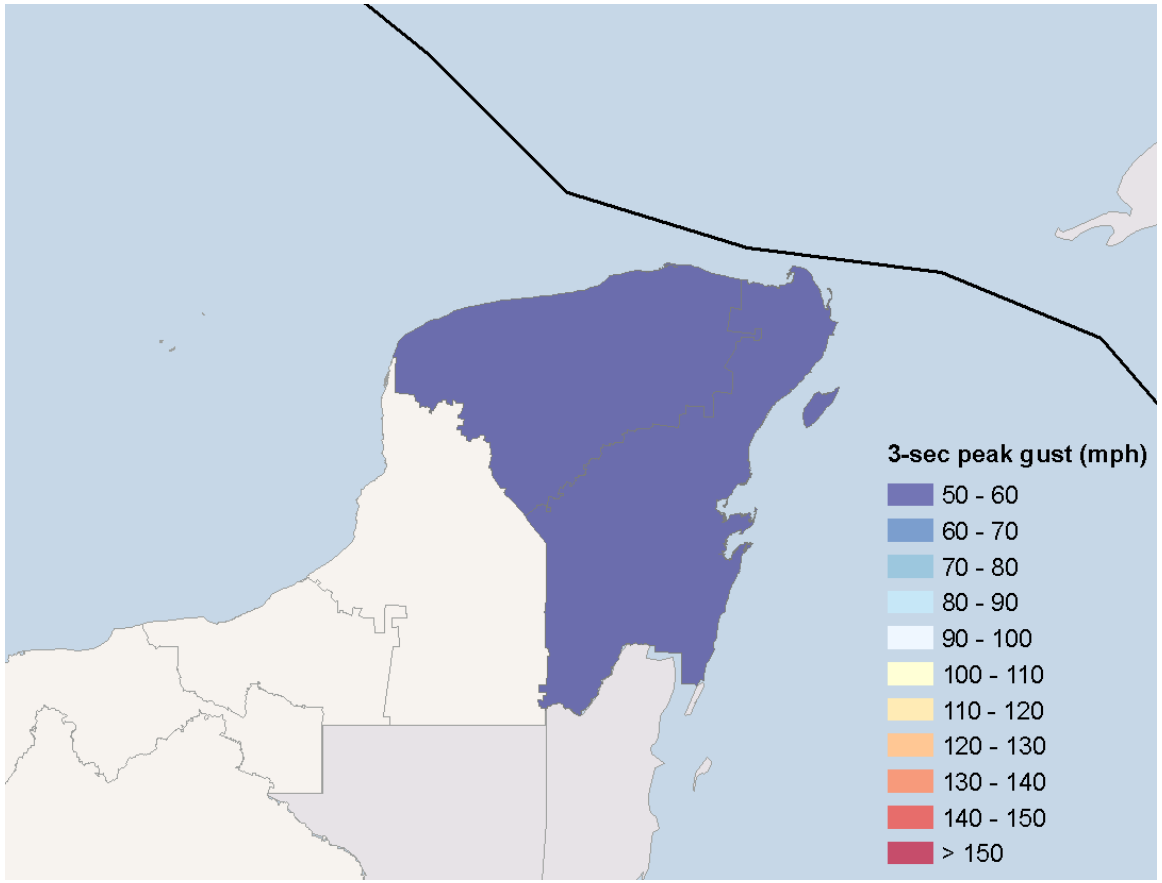


- Final aggregate hazard estimate the *most representative* for each aggregate area
- Values are weighted by exposure based on the line of business

IMPACT OF AGGREGATE HAZARD ON HAZARD FOOTPRINT

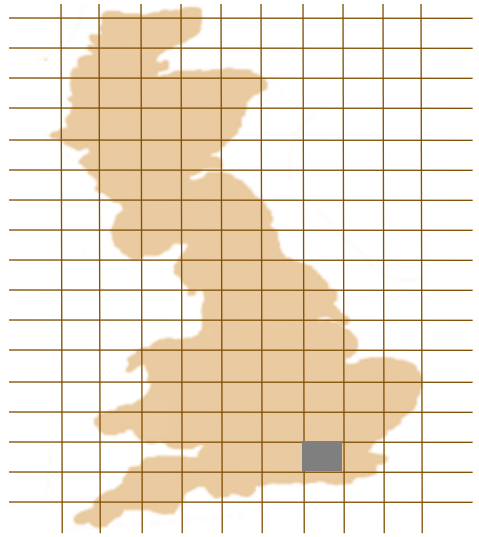


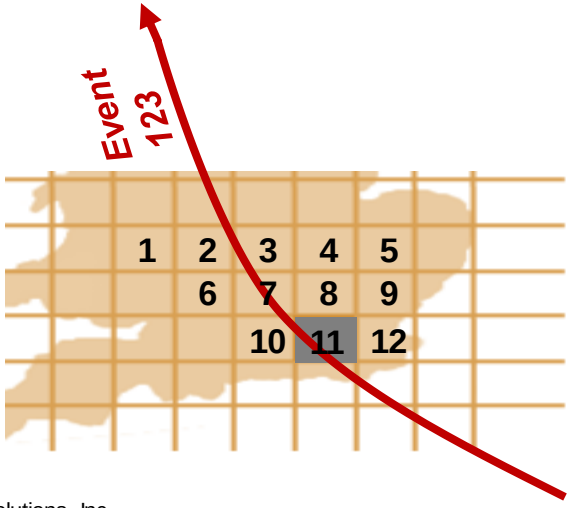
Detailed Geocoded Exposure



CRESTA Geocoded Exposure

Summary of Geocoding and Hazard Retrieval





Peak wind gust

VRG Cell	Event 122	Event 123	Event 124
10	60	74	63
11	70	92	69
12	75	87	81

VULNERABILITY MODULE

VULNERABILITY MODULE

DEFINE PERIL	APPLY EXPOSURE	ASSESS HAZARD	CALCULATE DAMAGE	QUANTIFY LOSS
				
STOCHASTIC EVENT MODULE	GEOCODING MODULE	HAZARD MODULE	VULNERABILITY MODULE	FINANCIAL MODULE

Things you can see…

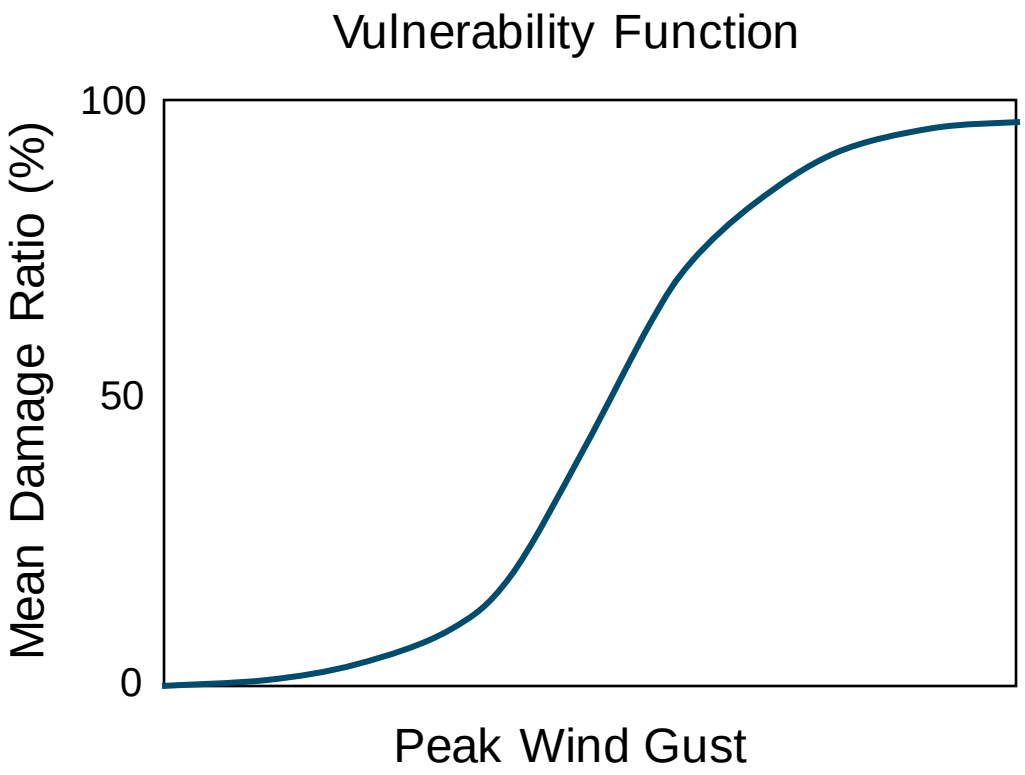
1. Construction
2. Number of stories
3. Roof (material, shape)
4. Chimney
5. Shutters/protection
6. Trees
7. External ornamentation
8. Siding/cladding

Which characteristics of this house would determine its reaction to a wind gust?

Things you can't see…

1. Year Built
2. Contents/Occupancy

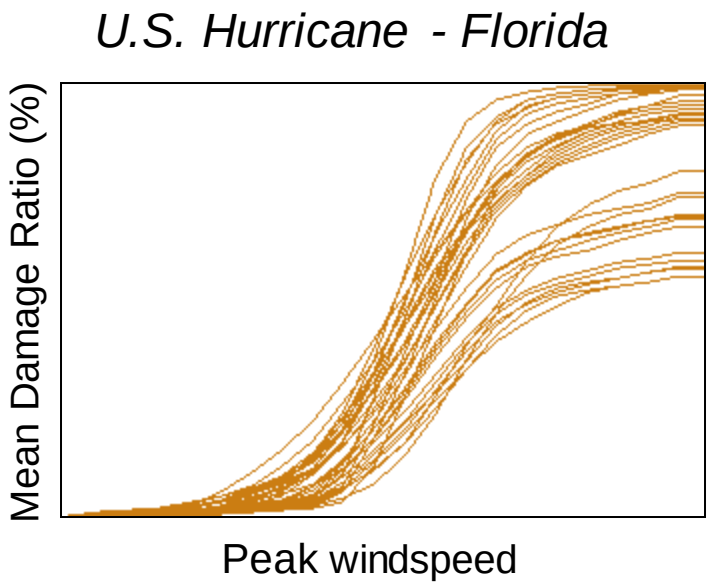
VULNERABILITY FUNCTIONS



- Relates the physical aspect of an event to the level of damage using a **vulnerability curve**
- Represented by the mean damage ratio (MDR):
- $$MDR = \frac{average\ loss}{replacement\ value}$$
- Given we know a location's replacement value and event hazard, we can determine MDR and, therefore, loss

CALCULATING BUILDING DAMAGE

- Vulnerability functions are uniquely defined by the four primary building characteristics:
  - Construction Class
  - Occupancy Class
  - Number of Stories
  - Year Built
  - (Floor Area)
- Each region has a suite of vulnerability curves for each peril



PRIMARY BUILDING CHARACTERISTICS

Occupancy

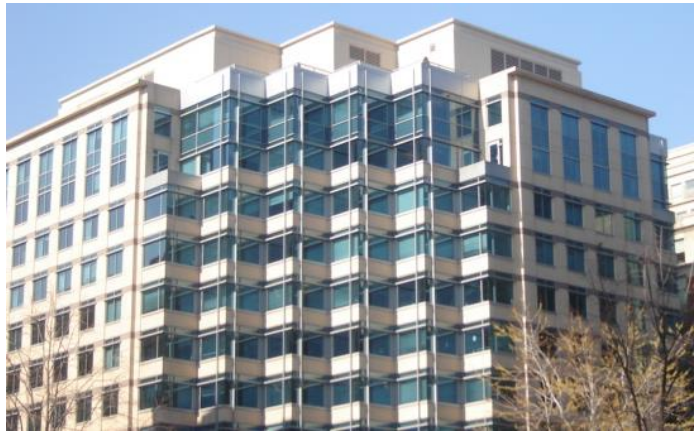
Construction

Year Built

Number of Stories

Single-Family Residential

Multi-Family Residential



Commercial

Industrial

PRIMARY BUILDING CHARACTERISTICS

- Occupancy
- **Construction**
- Year Built
- Number of Stories

Masonry

Reinforced concrete

Light metal

Wood

Steel

PRIMARY BUILDING CHARACTERISTICS

- Occupancy
- Construction
- **Year Built**
- Number of Stories

Seismic design code changes for sprinklers in the US

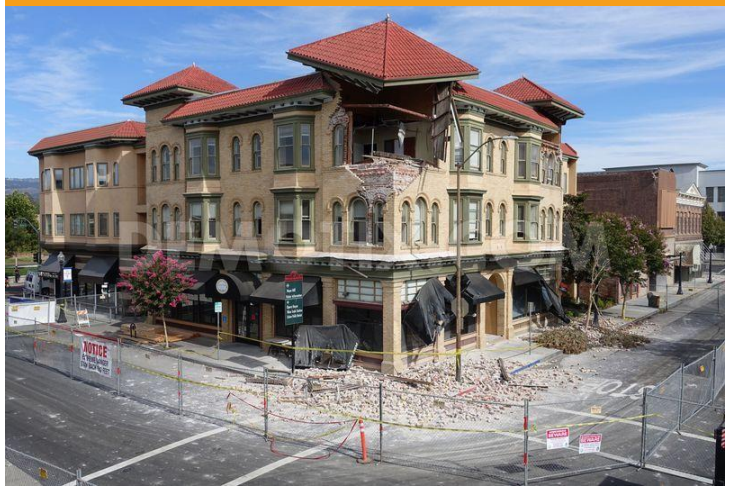
Year of construction	Comments
Up to 1953	• No seismic design guidance included in the dominant design standard for sprinkler systems
1954–1993	• Seismic bracing guidance included with incremental changes to seismic requirements after notable earthquake events
1994–Present	• Improvement in seismic bracing requirements, particularly with respect to smaller branch lines susceptible to damage during seismic events • Northridge earthquake resulted in better enforcement of design code especially in areas with prominent seismic hazards such as California

PRIMARY BUILDING CHARACTERISTICS

- Occupancy
- Construction
- Year Built
- **Number of Stories**

COVERAGE TYPES

Buildings



Contents

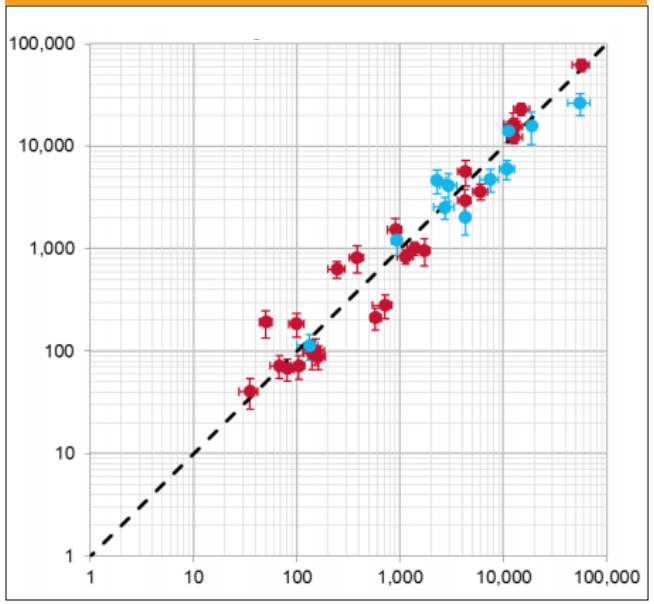
Business Interruption

BUILDING THE VULNERABILITY CURVES

Three key components:

Engineering Studies & Scientific Research

Calibration with Historical Claims Data

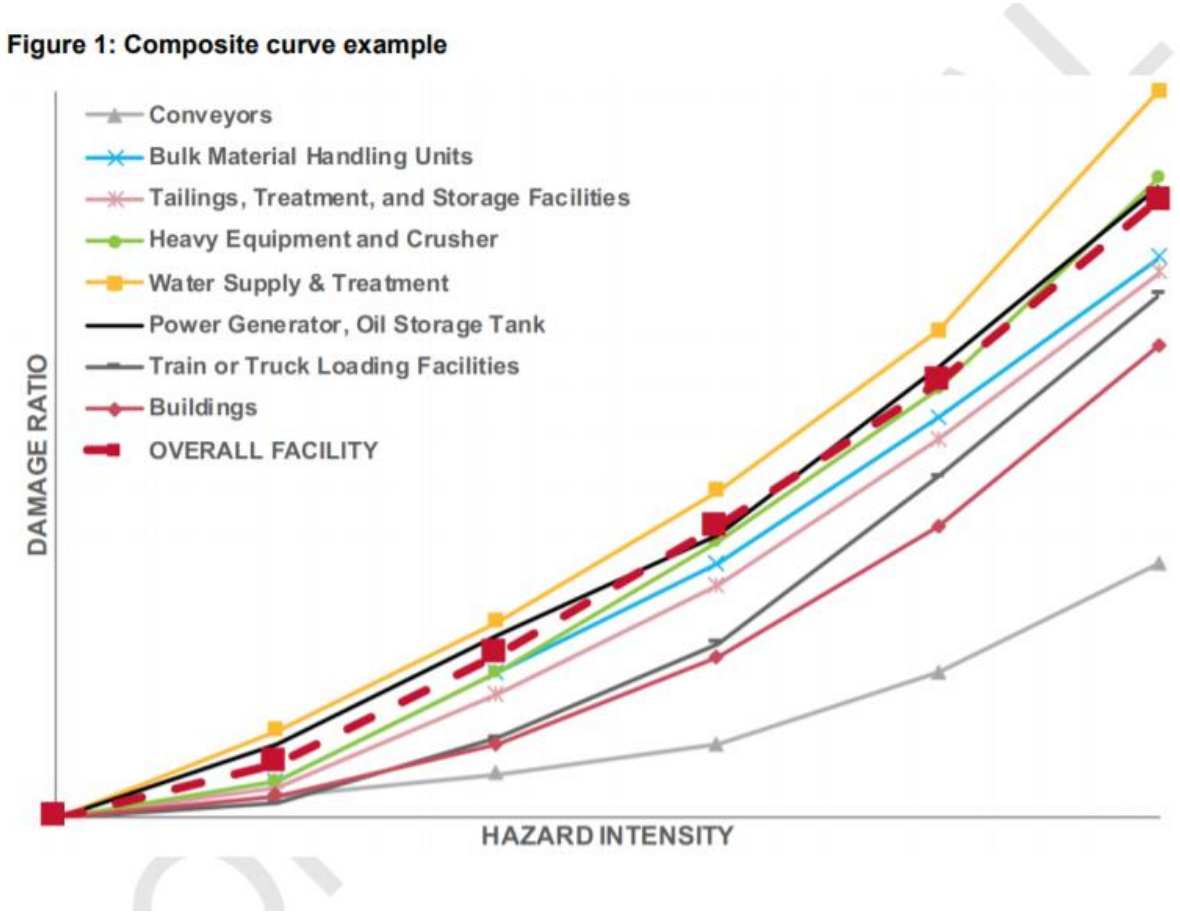


Expert Opinion

COMPONENT-BASED VULNERABILITY

Used for e.g. Industrial Facilities Model

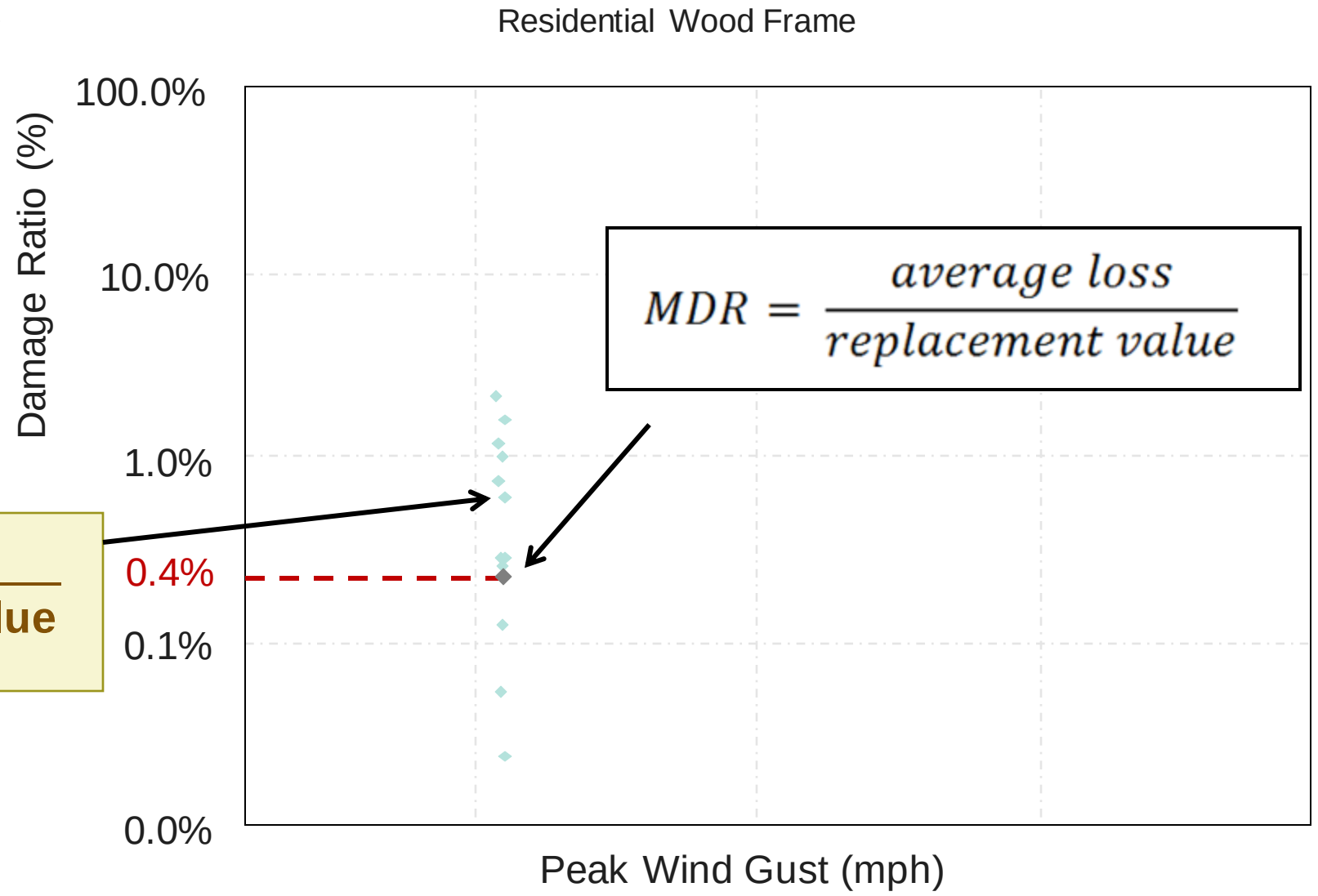
- Divide the occupancy class into structure and contents components
- Assess performance of each primary facility component.
- Combine individual curves to determine the damage function of the facility as a whole



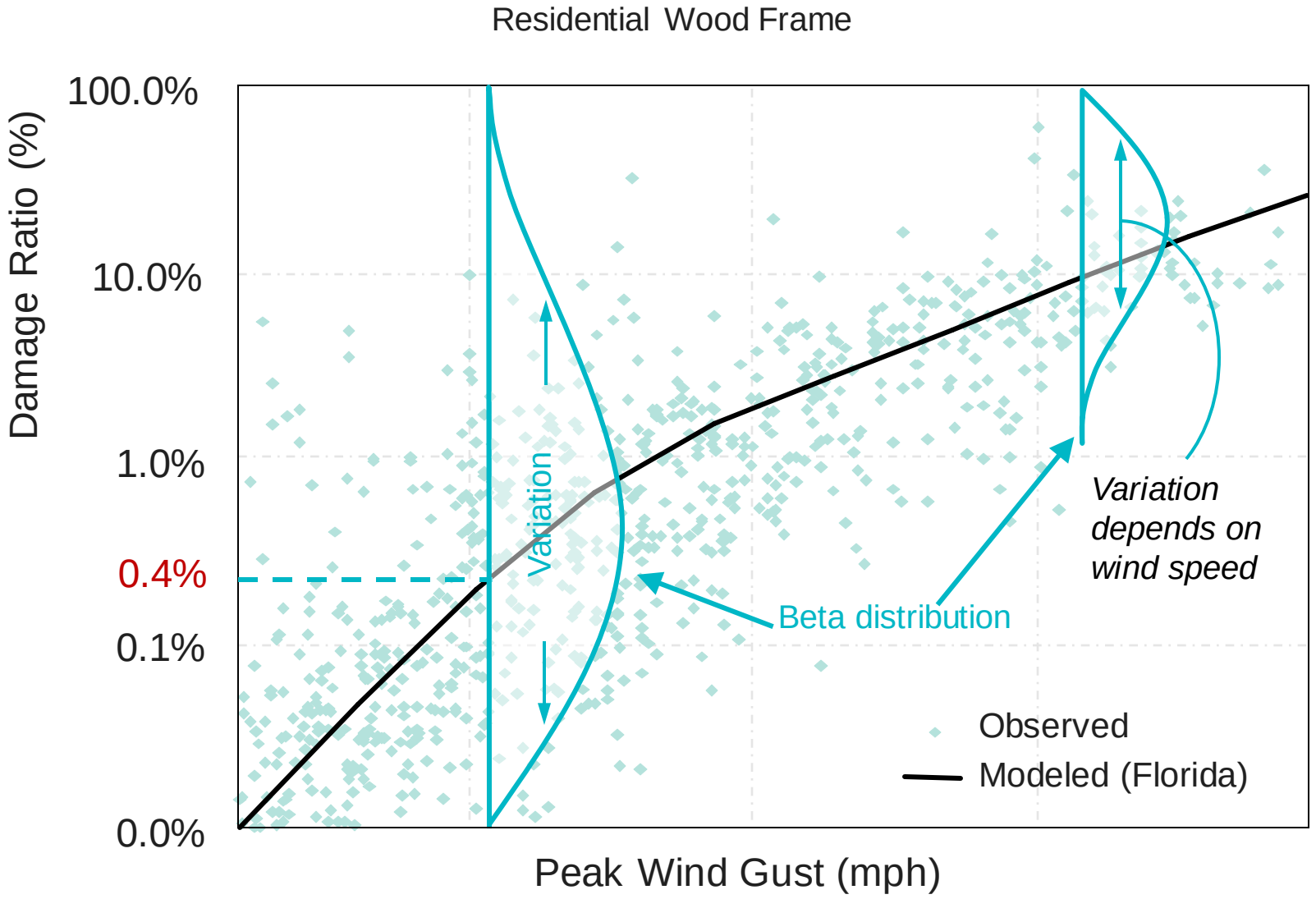
CLAIMS TO CURVES

- From claims data:
  - Damage amount (loss)
  - Replacement value

$$\text{damage ratio} = \frac{\text{loss}}{\text{replacement value}}$$

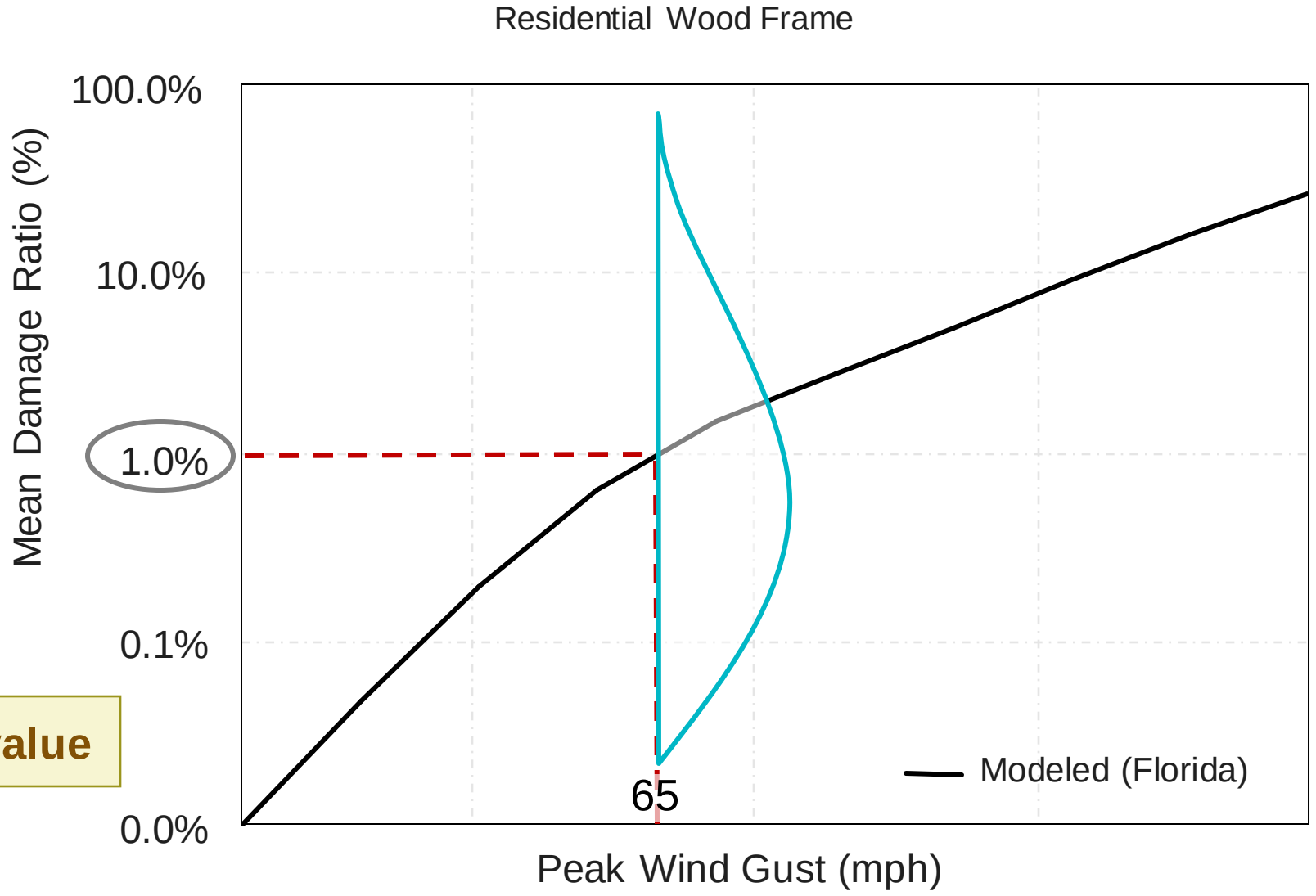


CLAIMS TO CURVES



CLAIMS TO CURVES

- Example:
  - Location with $1M TIV (replacement value)
  - Event 123 impacts location with 65 mph wind



mean loss = MDR * replacement value

= 1.0% * $1M

= $10,000 *…this gets passed to the financial model*

What other information might you want to capture?

EXAMPLES OF SECONDARY MODIFIERS

U.S. Hurricane

- Construction Quality
- Roof Covering
- Roof Age
- Roof Geometry
- Roof Anchors
- Cladding Type
- Wind Missiles

U.S. Earthquake

- Construction Quality
- Soft Story
- Sprinkler Type
- Structural Upgrade
- Frame-foundation Connection
- URM Retrofit
- Base Isolation

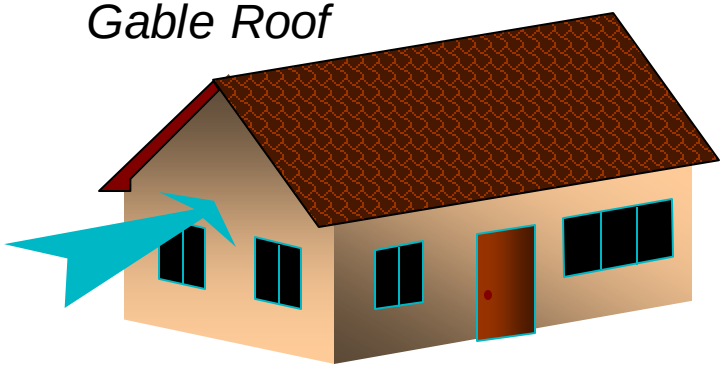
Europe Windstorm

- Roof Covering
- Roof Age
- Roof Geometry
- Cladding Type
- Architectural elements
- Wind Missiles

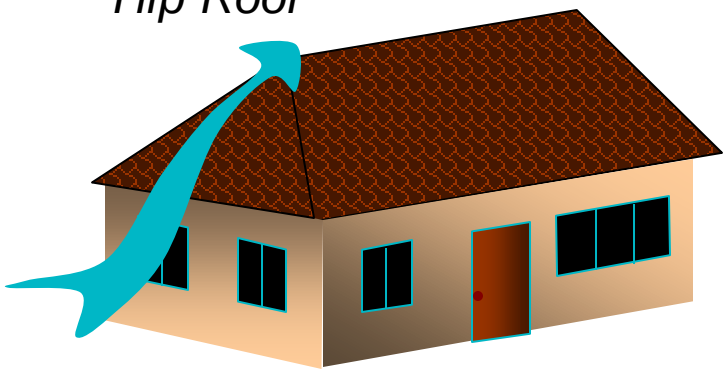
SECONDARY MODIFIERS

- Typically building characteristics that describe a location in more detail
  - *Mitigation elements (e.g. wind shutters, bracing)*
  - *Aesthetic elements (e.g. roof shape, ornamentation)*
  - *Surrounding elements (e.g. tree density)*
- Indicate whether a location will react better *or* worse than expected
- Can only be applied if *all four* primary characteristics are known

Gable Roof

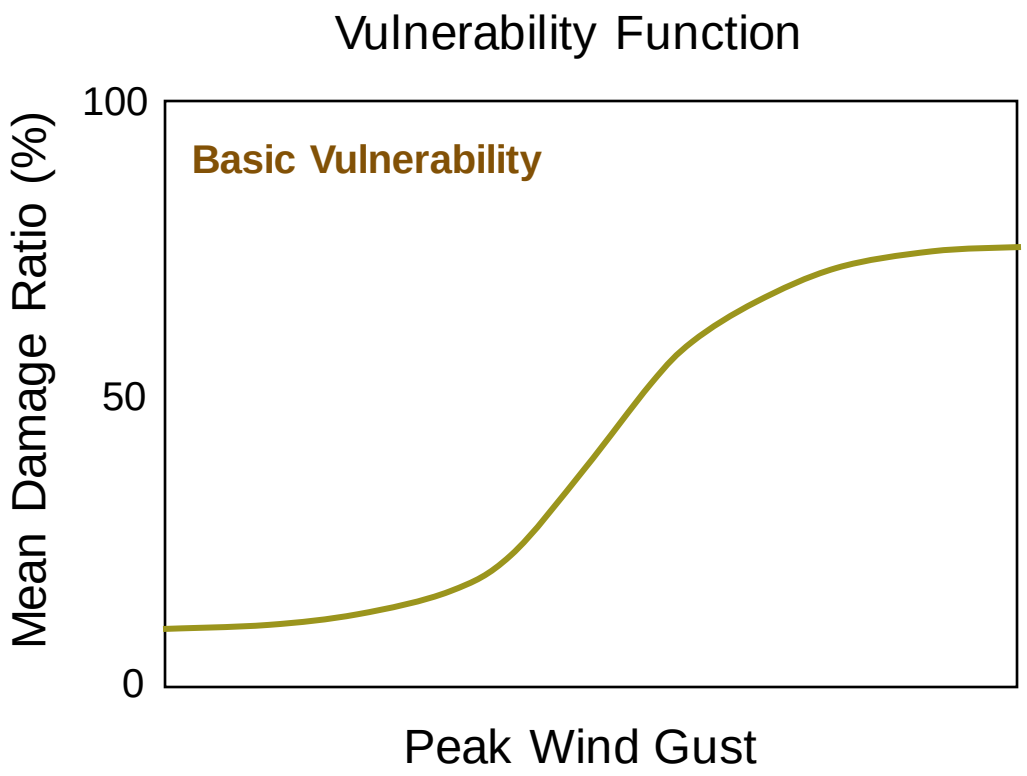


Hip Roof



SECONDARY MODIFIERS – IMPACT ON VULNERABILITY

- Scaling factors apply to the selected vulnerability function
- This may apply to all or part of the curve



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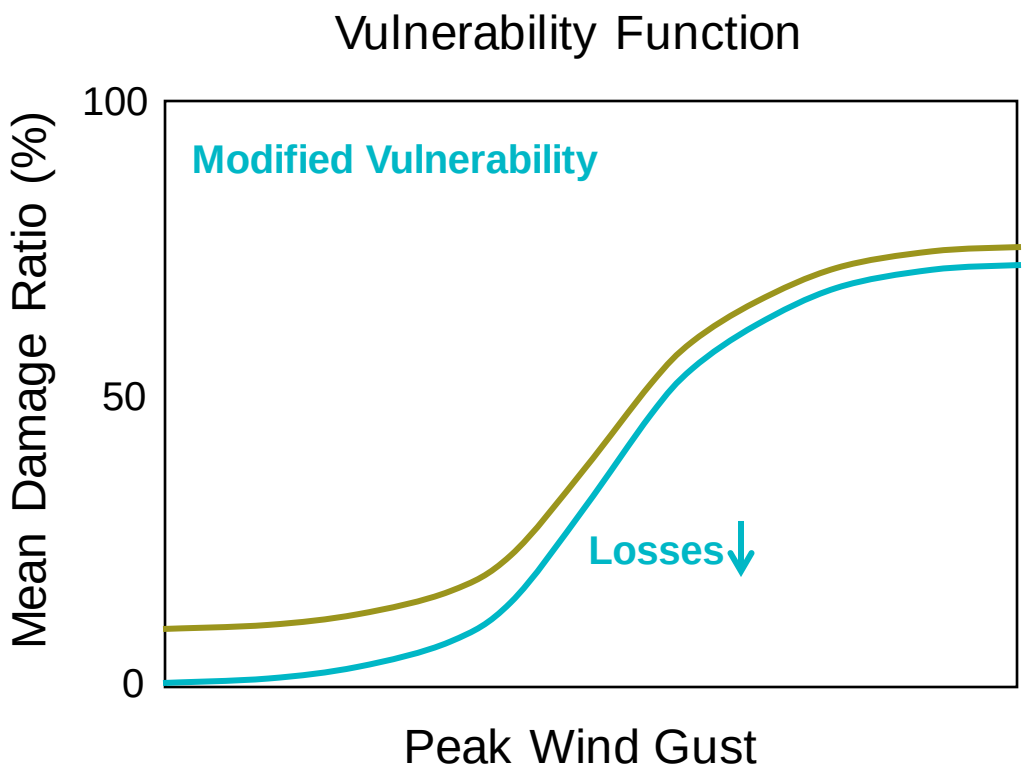
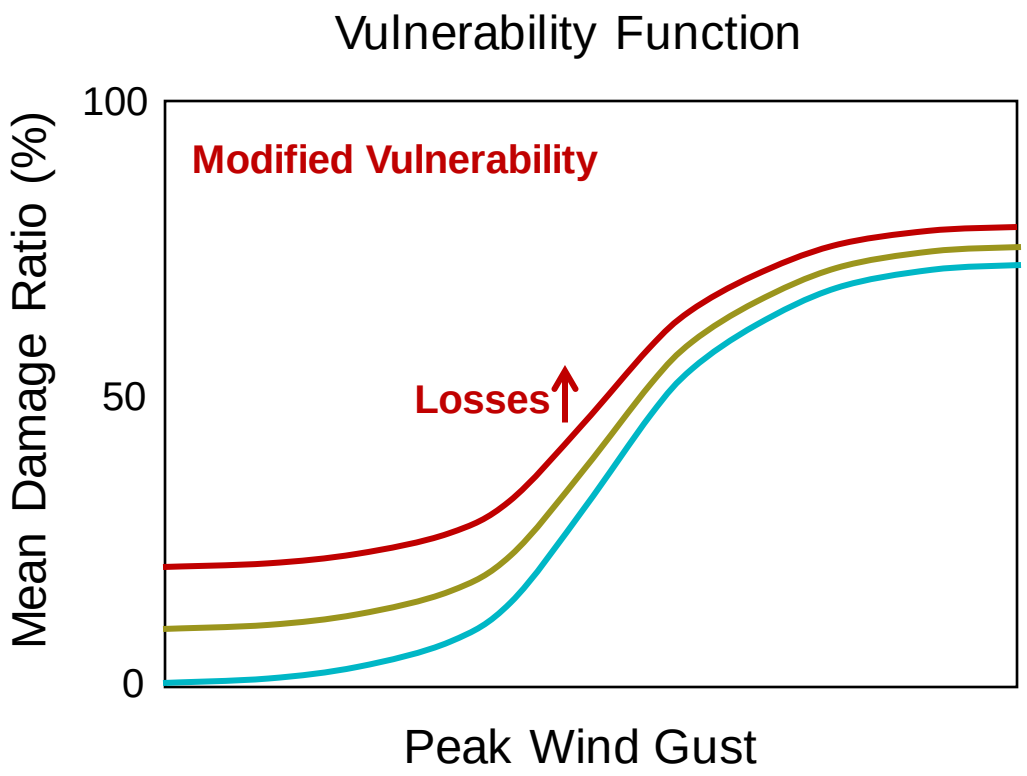


SECONDARY MODIFIERS – IMPACT ON VULNERABILITY

- Scaling factors apply to the selected vulnerability function
- This may apply to all or part of the curve
- Losses can increase or decrease as a result of secondary modifiers



SPECIALTY VULNERABILITY SECONDARY MODIFIERS

The Industrial Facilities Model and Marine Cargo and Specie Model both support specialised modifiers for industrial / cargo / specie risks.

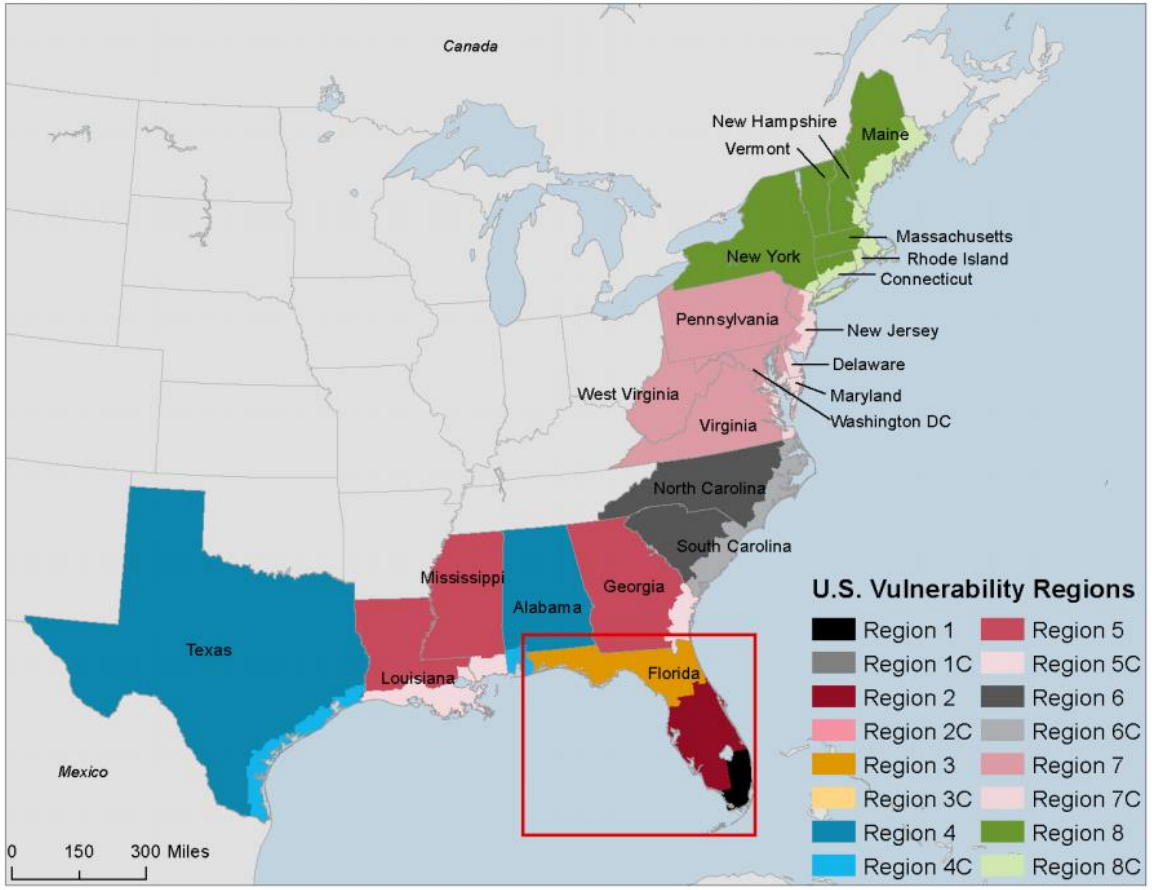
- Not all primary modifiers are needed for these secondary modifiers to be utilised
- These modifiers are highly encouraged where information is known and can have a significant impact on losses

Table 12: Secondary modifiers, options and typical impacts on average annual loss (AAL) – cargo exposure

Marine Secondary Modifiers	Options	Range of MDR Adjustment – Cargo					Usage Justification
		Wind	Surge/Flood *	Earthquake	Hail	Tornado	
Salvage Potential	Unknown						Salvage value that differs from average due to policy provisions or unique exposure characteristics.
	Lowest						
	Low						
	Average (default)						
	High						
	Very High						
Cargo and Specie Packaging	Unknown						Packaging measures that differ from average.
	Deficient						
	Standard (default)						
	Superior						
Cargo and Specie Protection	Unknown						Exposure that typically is protected or neglected.
	None						
	Typical (default)						
	Well Protected						
Sprinkler Type	Unknown (default)						Sprinkler type, if known.
	Wet						
	Dry						

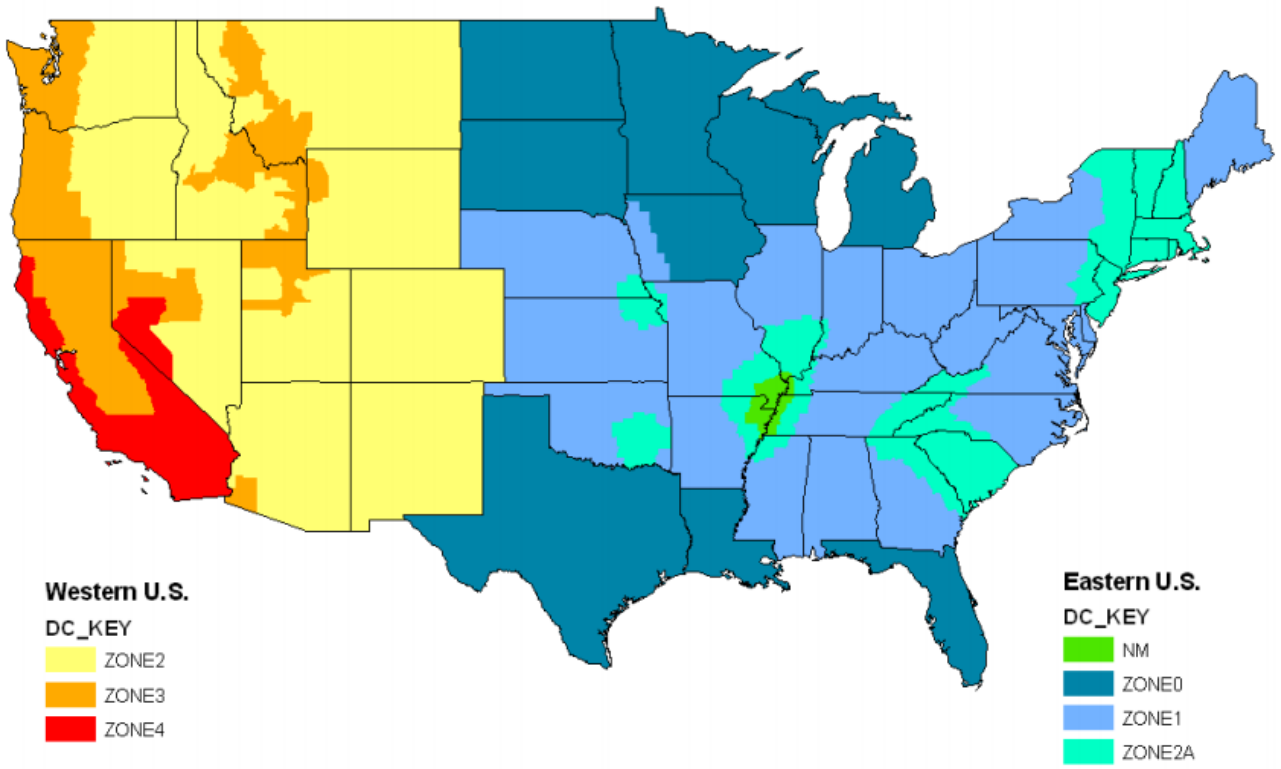
* While the secondary modifier impacts are not identical for surge and flood perils, the impacts are very similar, and fall into the same bandings in Table 12 and Table 13.

VULNERABILITY REGIONS: US HURRICANE



- Unique curve for each combination of the four primary building characteristics in each region
- Regions based on available knowledge:
  - *Building Code Standards and Enforcement*
  - *Claims Data*

VULNERABILITY REGIONS: US EARTHQUAKE

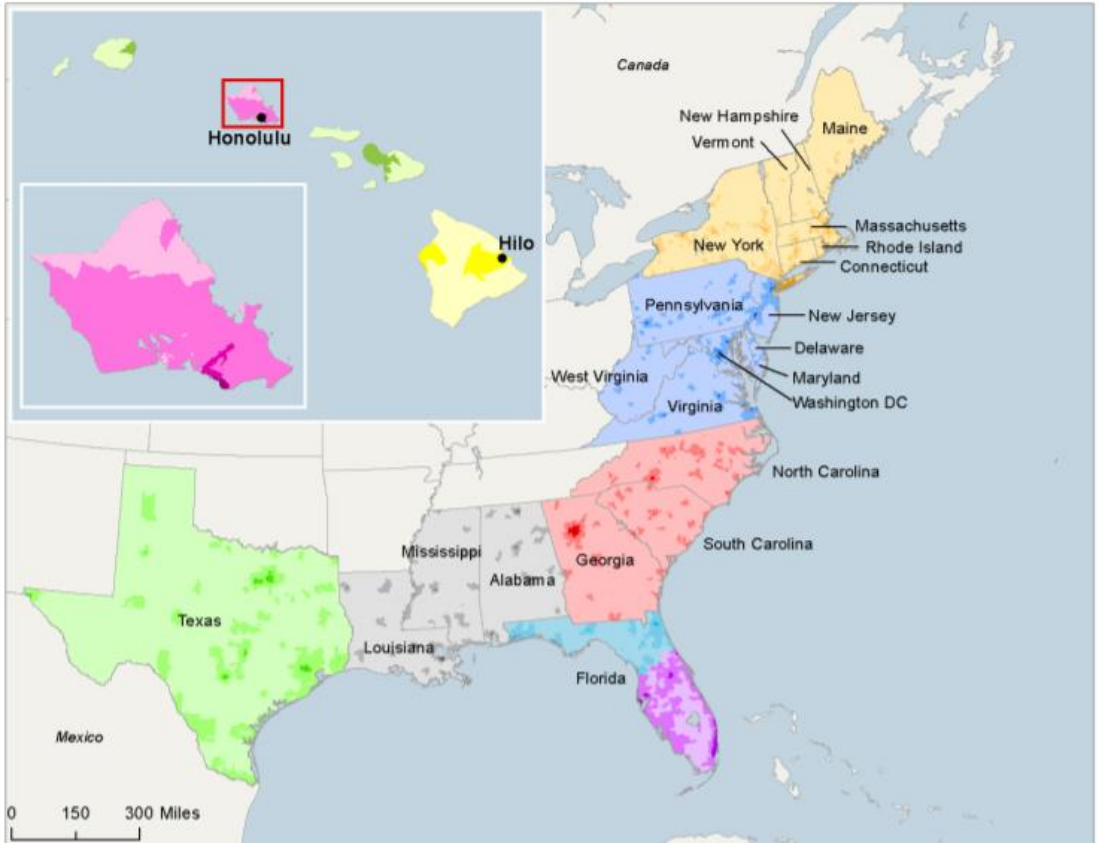


- Unique curve for each combination of the four primary building characteristics in each region
- Regions based on available knowledge:
  - *Building Code Standards (Seismic Design Codes) and Enforcement*

UNKNOWN PRIMARY MODIFIERS

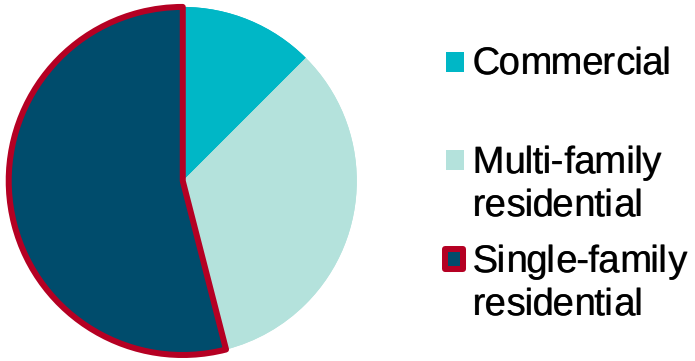
- If any of the four primary characteristics are not known: the **Building Inventory** is invoked
  - A composite vulnerability function is computed using what information is available
  - Uses valid address information to estimate likely building characteristics based on regional building characteristic statistics
  - Secondary modifiers are not applied

Figure 21: U.S. building inventory regions

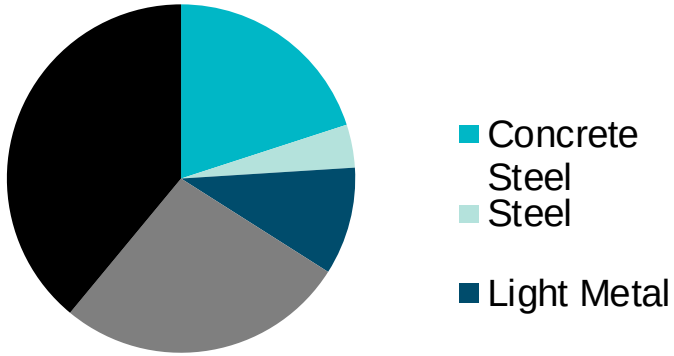


BUILDING INVENTORY

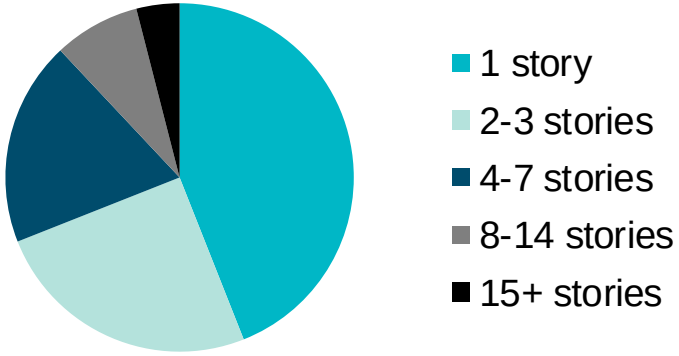
Occupancy Type



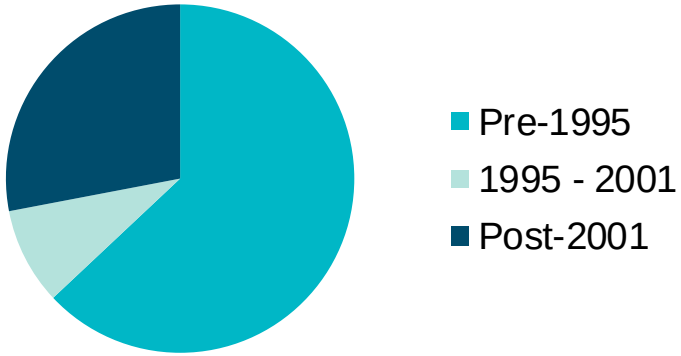
Construction Class

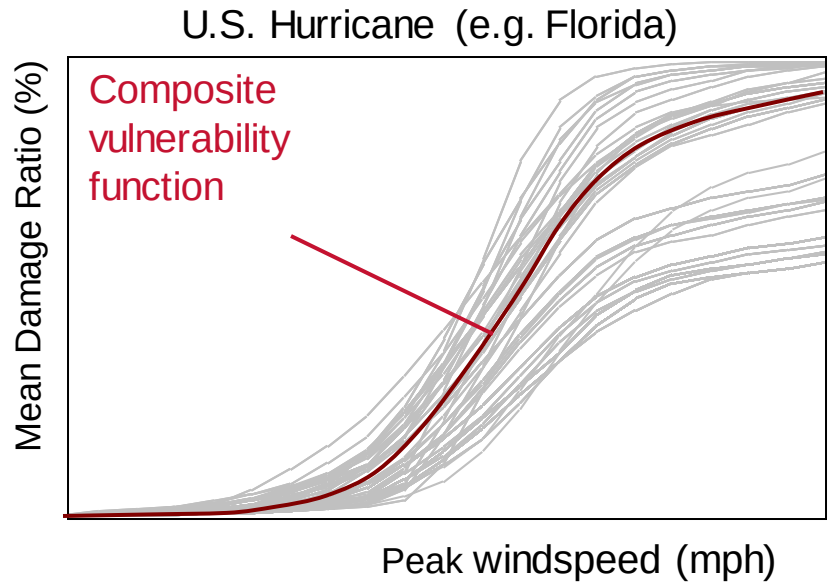


Number of stories



Year Built

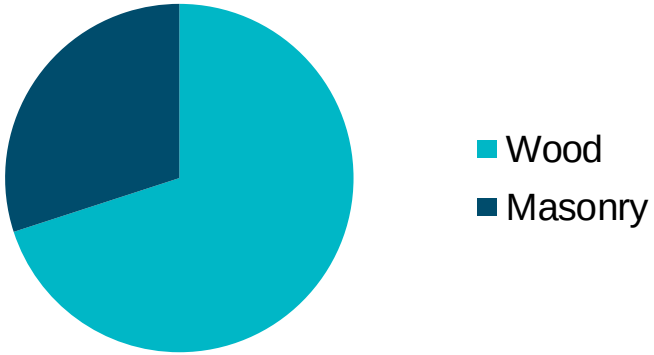




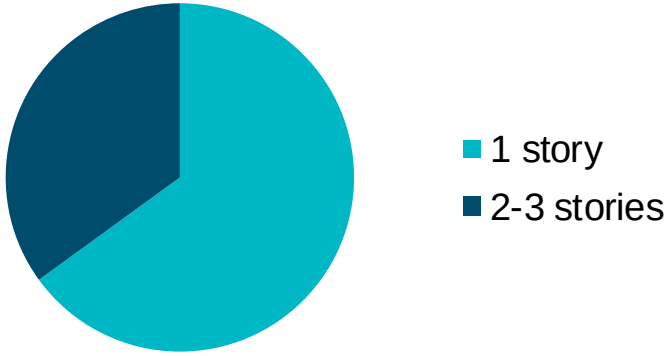
BUILDING INVENTORY

Single-family residential

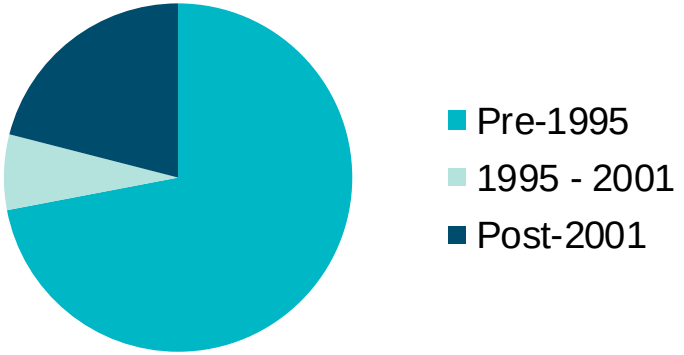
Construction Class



Number of stories

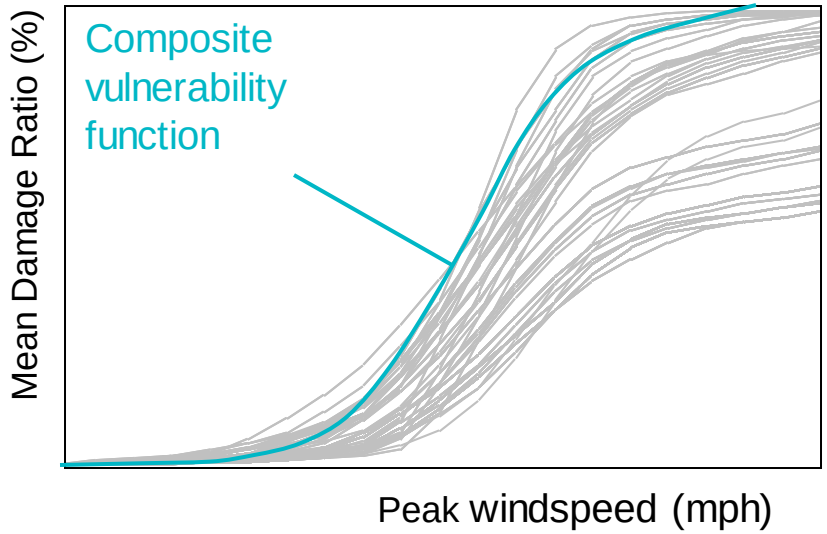


Year Built



Note: Not real inventory data

U.S. Hurricane (e.g. Florida)



BUILDING INVENTORY REGIONS

CBD

Urban

Suburban

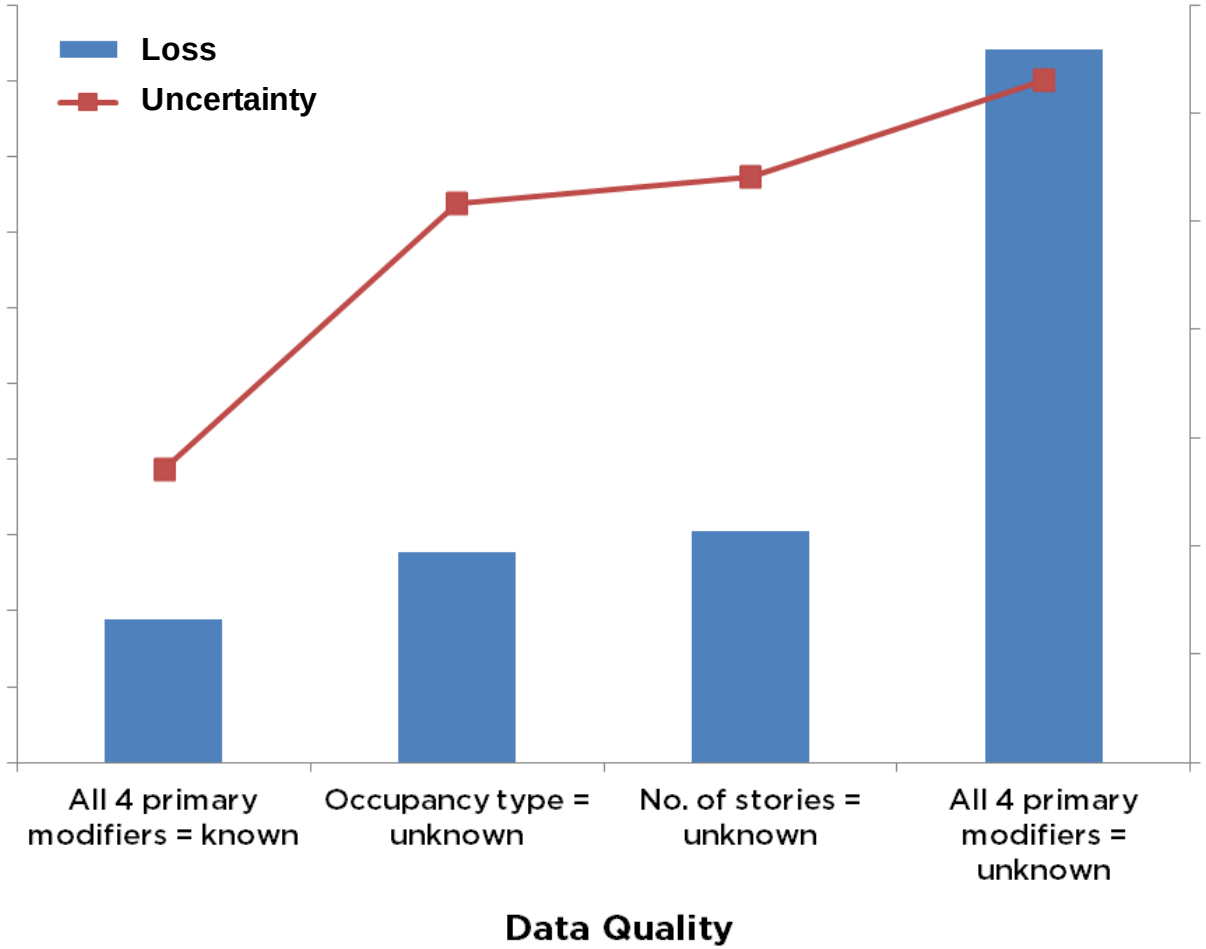
Rural

Recap:

Building Inventory Region – When a primary characteristic is unknown, what does the model assume?

Vulnerability Region – The same four primary characteristics provide different curves in different regions

IMPORTANCE OF PRIMARY BUILDING CHARACTERISTICS



Data quality

- General Commercial
- Steel Frame
- 102 stories
- Built 1931

#	Occupancy Description	Construction Description	No. of stories	Year Built	Average Annual Loss Difference
1	Professional, Technical & Business Services	Masonry	105	1931	465%
2	General Commercial	Masonry	1	Unknown	225%
3	Permanent Dwelling (single family housing)	Reinforced Concrete	Unknown	Unknown	35%
4	Professional, Technical & Business Services	Reinforced Concrete	102	Unknown	-23%
5	General Commercial	Unknown	11	1996	102%
6	Telephone & Telegraph	Unknown	Unknown	1931	132%
7	Entertainment & Recreation	Unknown	1	Unknown	124%
8	Unknown	Unknown	Unknown	Unknown	76%
9	General Commercial	Unknown	102	1931	8%

POST-EVENT LOSS AMPLIFICATION

Following a major catastrophic event, claims costs can exceed the normal cost of settlement

Evacuation Centre post Tohoku 2011

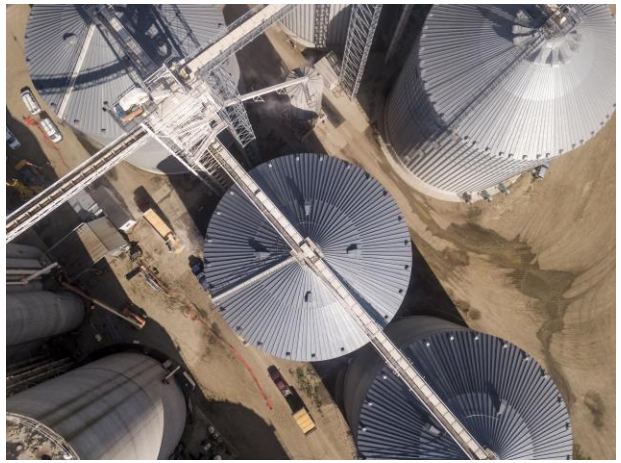
1. **Economic demand surge**
   - Cost of building materials and labour increases as demand exceeds supply. *This factor has the biggest overall impact*
2. **Claims inflation**
   - Cost inflation due to the difficulties in fully adjusting claims following a catastrophic event
3. **Super CAT scenarios**
   - A complex collection of factors (e.g. evacuation effects, economic downturns in urban areas) causes increased loss (primarily to BI coverage)

WHAT ARE THE SPECIALTY VULNERABILITY MODELS?

DEFINE PERIL	APPLY EXPOSURE	ASSESS HAZARD	CALCULATE DAMAGE	QUANTIFY LOSS
				
STOCHASTIC EVENT MODULE	GEOCODING MODULE	HAZARD MODULE	VULNERABILITY MODULE	FINANCIAL MODULE

Vulnerability 'plug-ins': the IFM, Marine Cargo, and BR models provide additional, specialized vulnerability curves that can be used when running peril models

INDUSTRIAL FACILITIES MODEL (IFM)



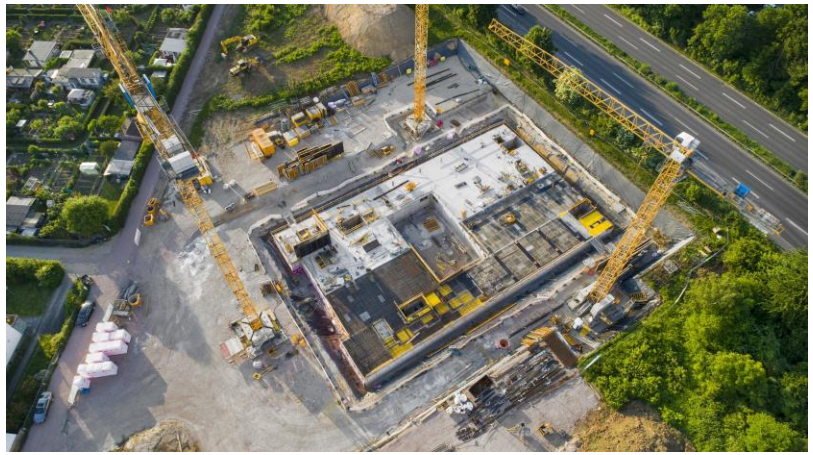
- Developed to capture the unique nature of industrial risks
- More accurate way of coding industrial exposures
  - Differentiates vulnerability of different industrial occupancy types
  - Captures relationships between building, M&E and stock damageability

MARINE CARGO AND SPECIE

The Marine Cargo and Specie Model captures the unique nature and diverse coverage of cargo and specie exposure:

- **200** unique damage functions per peril-region combination covering **95** regions
- **18** categories of products, **12** storage types, secondary modifiers, **2,000+** combination
- Unique vulnerability scheme with specific occupancy and construction fields
- Secondary modifiers allow for granular risk differentiation

BUILDERS RISK MODEL



Builders Risk Model assesses risk for buildings and facilities that are under construction

- Standard approaches to exposure and vulnerability modelling cannot adequately quantify the risk for **construction projects**
- Builders Risk Model developed to capture the risk posed and generate probabilistic estimates of catastrophe losses
- Projects are broken into critical construction milestones
- Quantify risk by project type, construction class, and phase of construction

INDUSTRY EXPOSURE DATABASES (IEDs)

- RMS view of insurance industry exposure by line of business
- IEDs available for major insurance markets of the world including the US, Canada, Caribbean, Europe and Japan
- Built from a range of industry and public data, the method varies for each country
- Industry Loss Curves (ILCs) produced from IEDs

MARINE PORT IED

Industrial Exposure Database for 185 of the worlds largest and strategically important ports

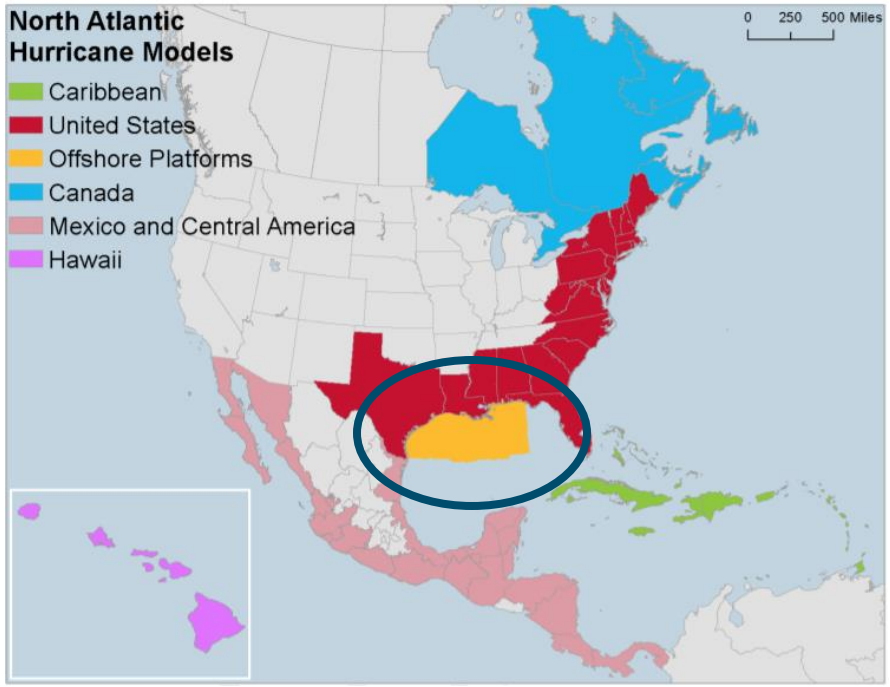
- Thousands of individually geocoded warehouses, distribution facilities, silos, tanks, and open lots…
- Information on average and peak exposure values to provide perspective on seasonality
- Shapefiles of global free ports and auto storage facilities

OFFSHORE PLATFORM MODEL

Offshore Platforms in the Gulf of Mexico as part of the North Atlantic Hurricane Model.

- The OP model uses the same event set and event rates as the NAHU model
- Hazard components: wind and wave
- Coverages: Physical Damage, Operators Extra Expense and BI

Additional Resources: IED and Helper Spreadsheet include information on active platforms, wells, and pipelines and positions of mobile rigs in the GoM



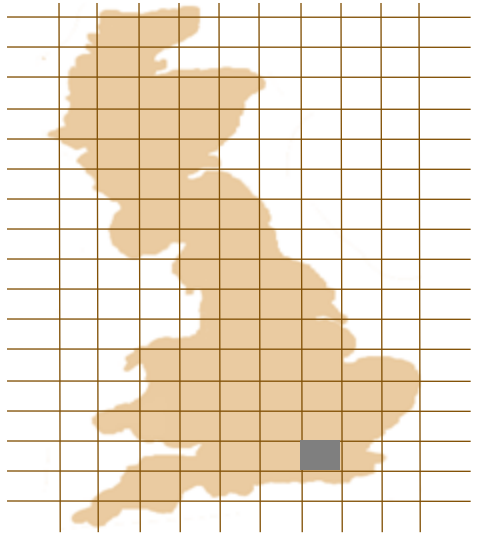
END TO END MODEL OPERATION

Importance of Geocoding in Catastrophe Models

DEFINE PERIL	APPLY EXPOSURE	ASSESS HAZARD	CALCULATE DAMAGE	QUANTIFY LOSS
				
STOCHASTIC EVENT MODULE	GEOCODING MODULE	HAZARD MODULE	VULNERABILITY MODULE	FINANCIAL MODULE
	Which events impact the location?	*What is the ground shaking at this location?*	*Which vulnerability region does this location fall in?*	*How much uncertainty is there around these losses?*

MODEL OPERATIONS: OVERVIEW

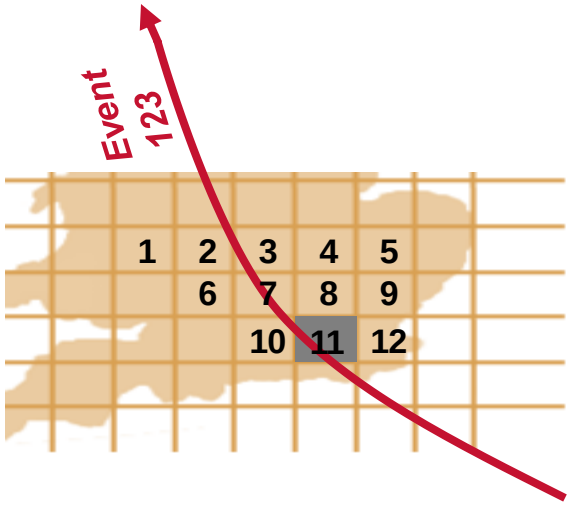
Turn address information into coordinates



MODEL OPERATIONS: OVERVIEW

Turn address information into coordinates

Use coordinates to lookup peak gust for event



Peak wind gust

VRG Cell	Event 122	Event 123	Event 124
10	60	74	63
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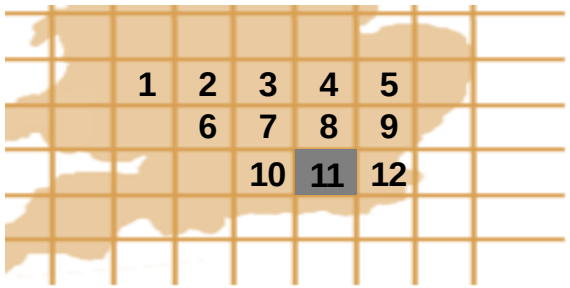
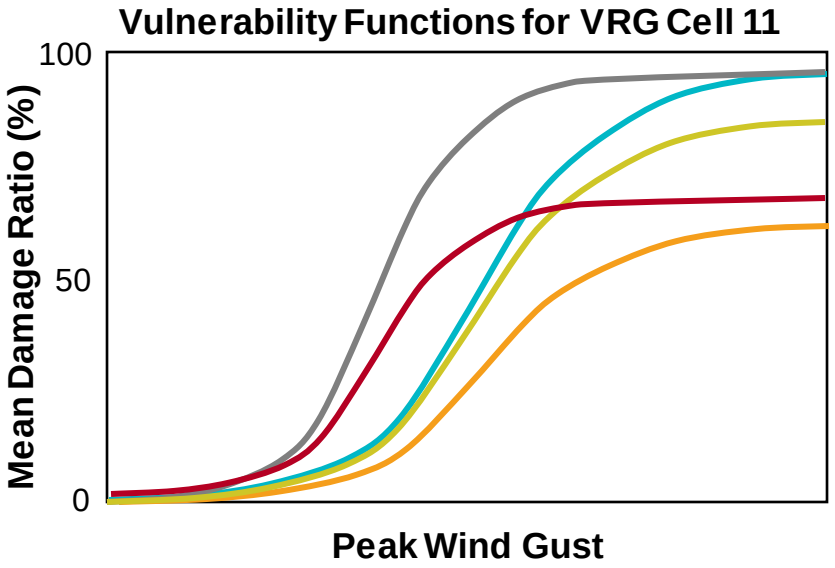
MODEL OPERATIONS: OVERVIEW

Turn address information into coordinates

Use coordinates to lookup suite of vulnerability curves

Use coordinates to lookup peak gust for event





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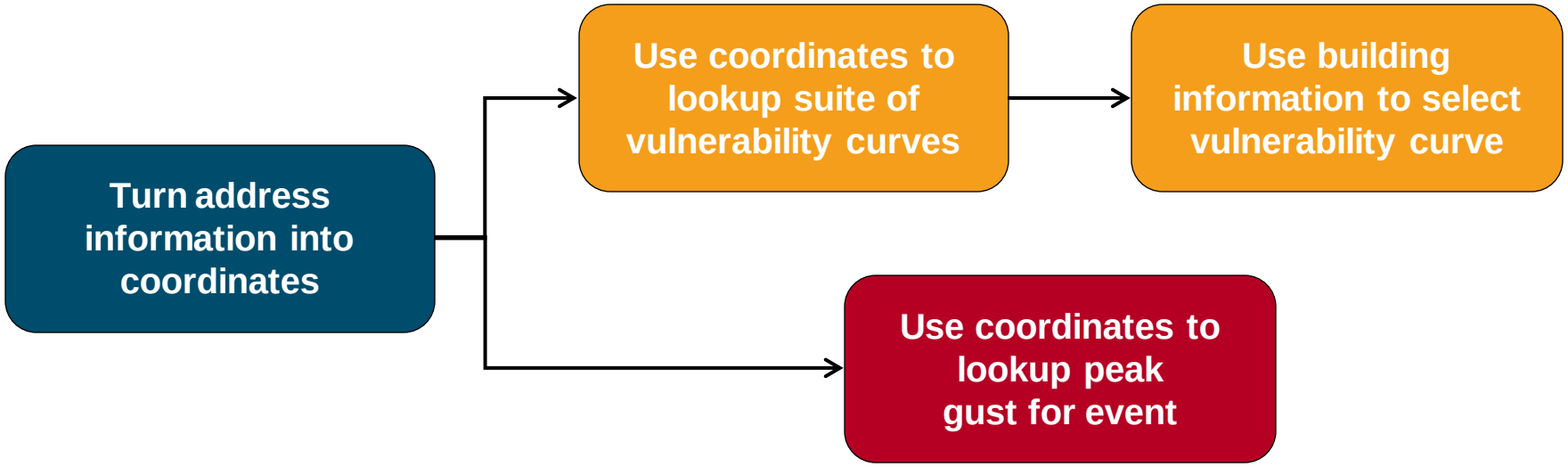

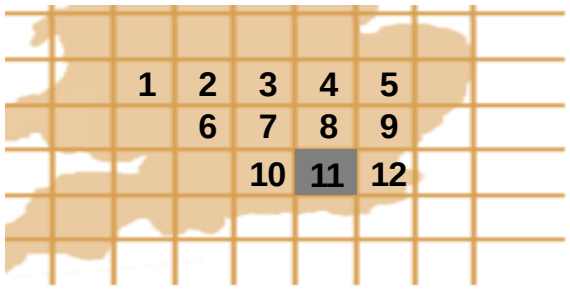

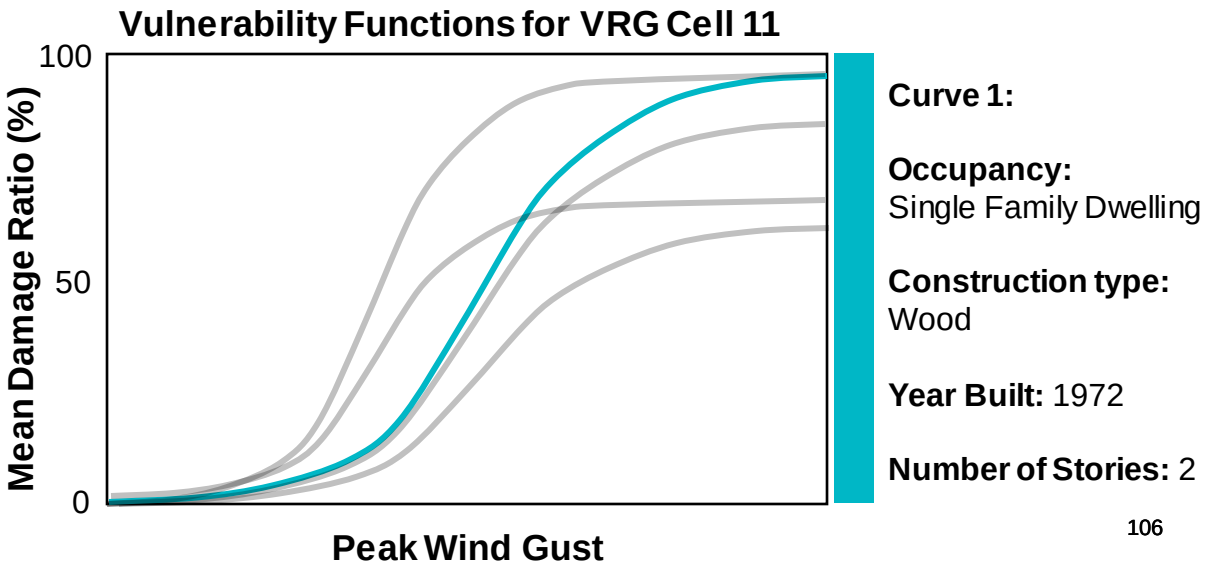

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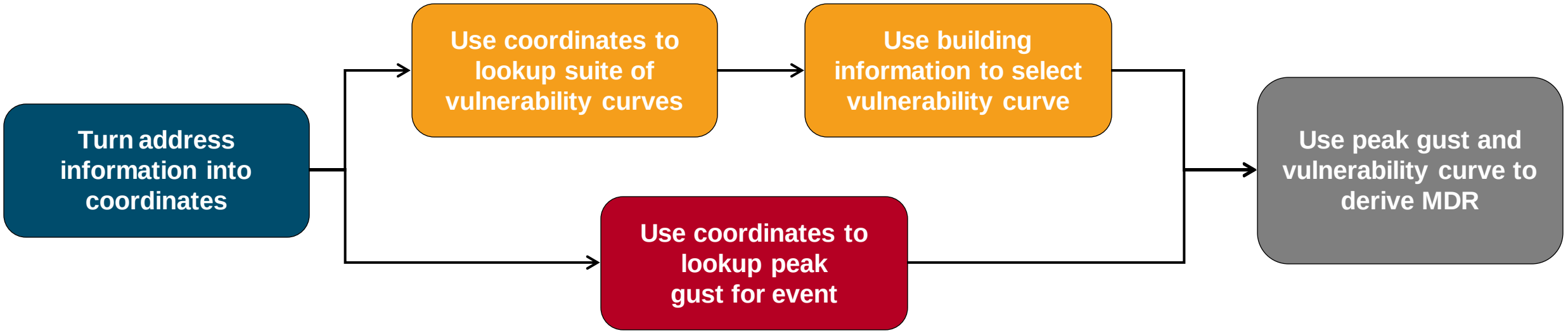

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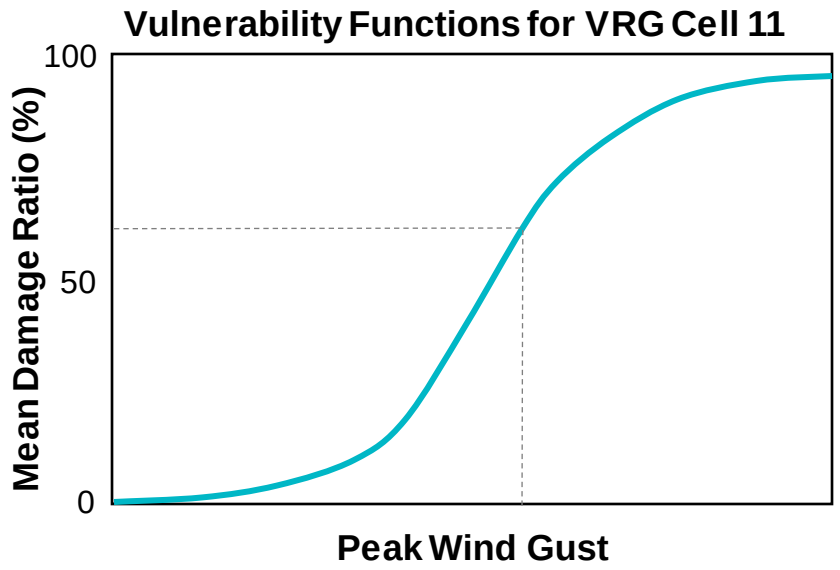


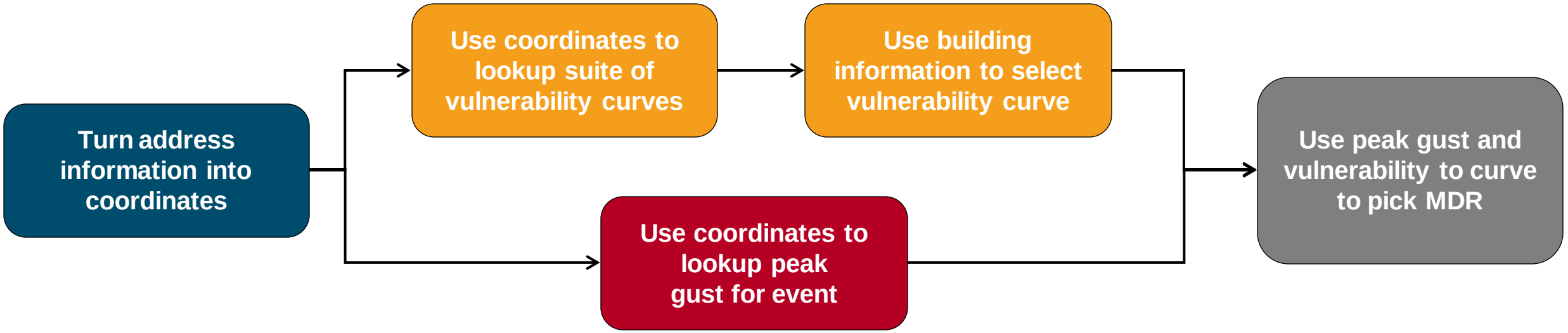
Mean Damage Ratio:

Mean Damage Ratio:
60%

Building Value:
$1M

Event 123 Loss:
60% x $1M = $600K

MODEL OPERATIONS: OVERVIEW



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- Eventually you end up with a loss for every event across every location
- Financial structures can then be applied, sharing the loss between insured, insurer and reinsurer
- Risk Modeler also generates statistics on your average annual loss and associated return period losses

FINANCIAL MODULE

CATASTROPHE MODELLING FRAMEWORK

DEFINE PERIL	APPLY EXPOSURE	ASSESS HAZARD	CALCULATE DAMAGE	QUANTIFY LOSS
				
STOCHASTIC EVENT MODULE	GEOCODING MODULE	HAZARD MODULE	VULNERABILITY MODULE	FINANCIAL MODULE

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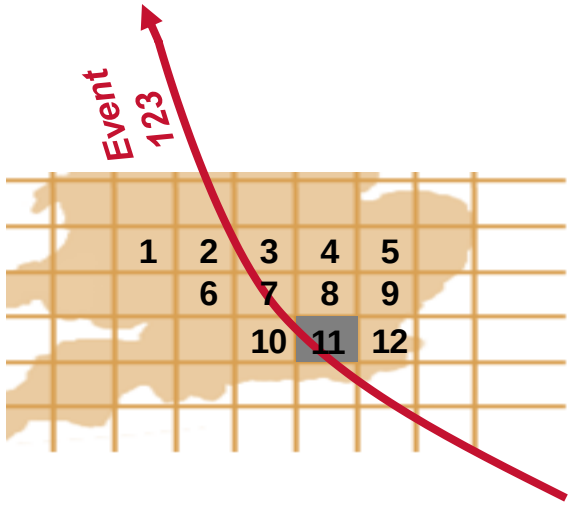

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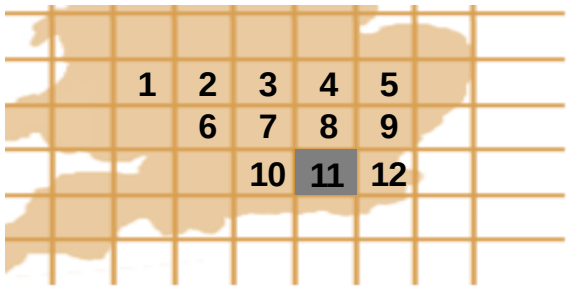

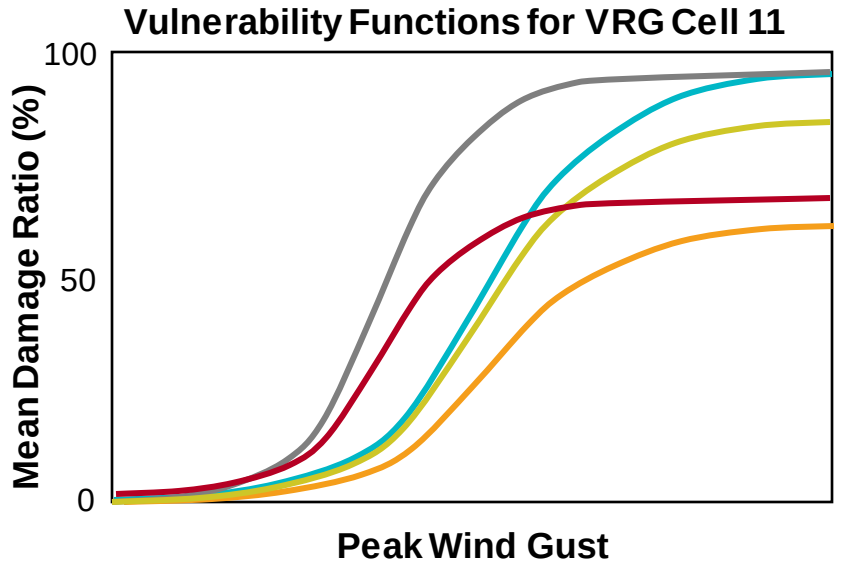

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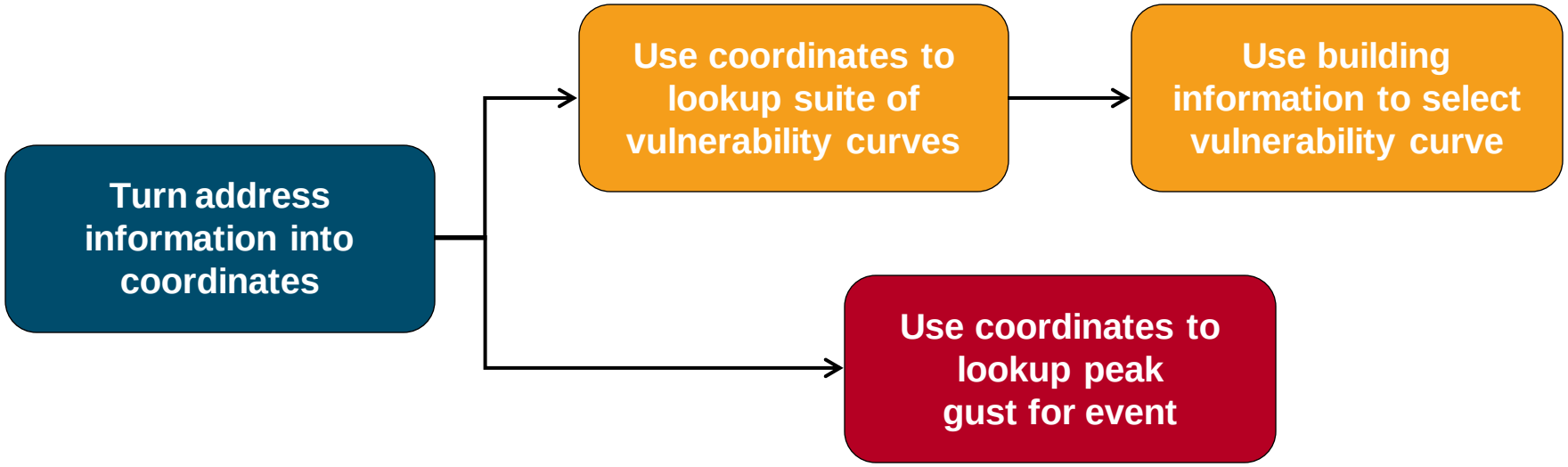

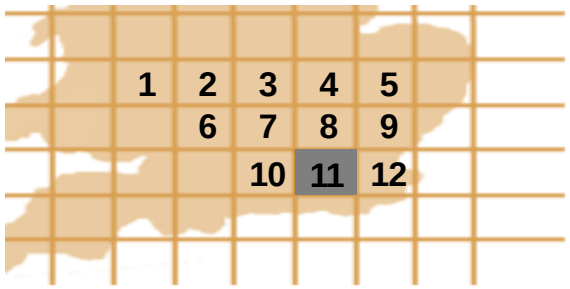

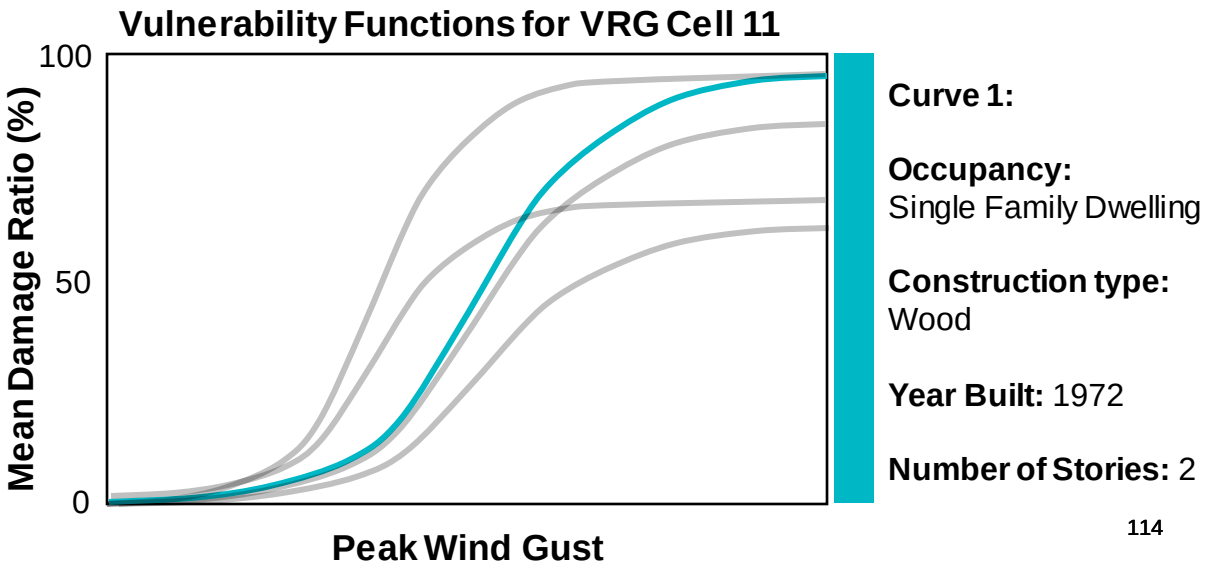

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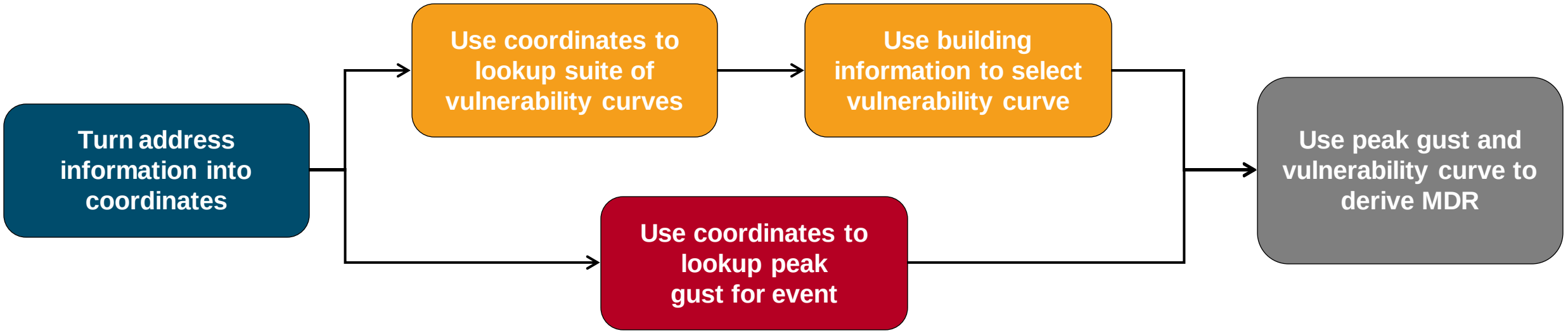

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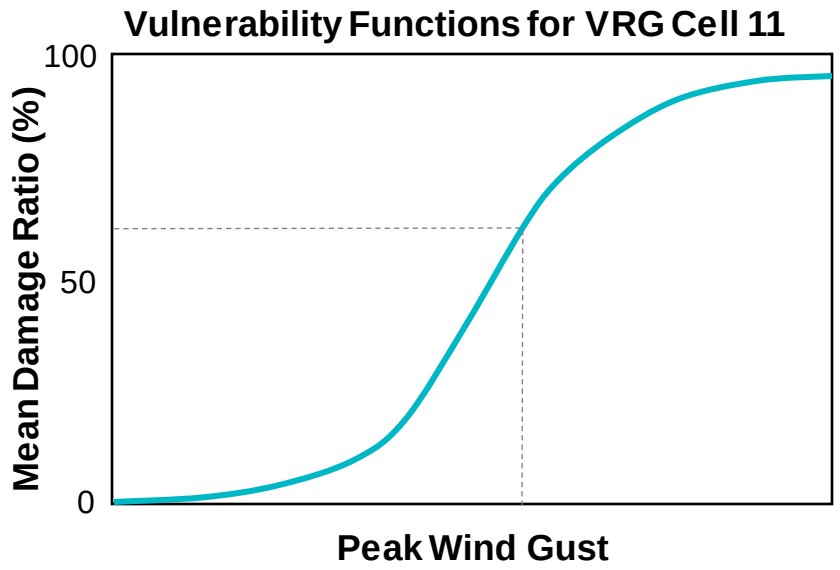

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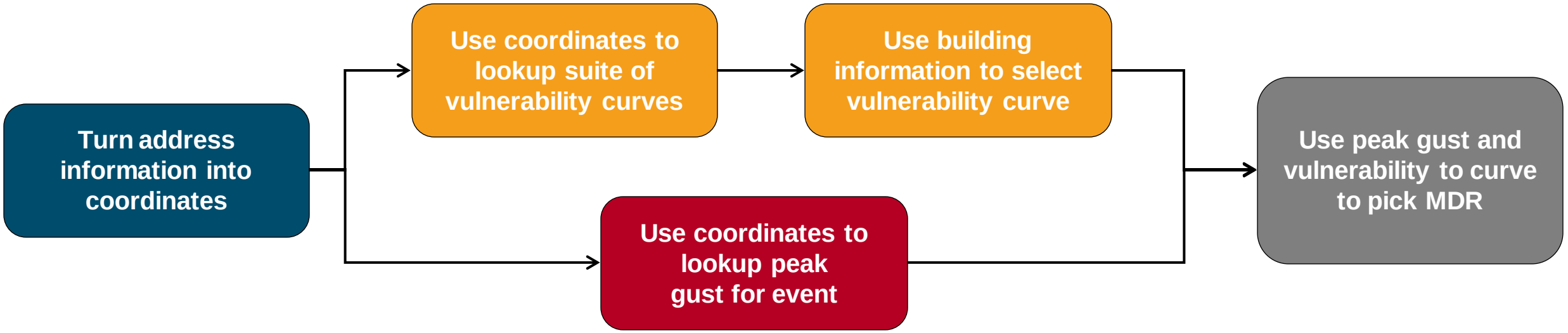

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FINANCIAL MODULE

DEFINE PERIL	APPLY EXPOSURE	ASSESS HAZARD	CALCULATE DAMAGE	QUANTIFY LOSS
				
STOCHASTIC EVENT MODULE	GEOCODING MODULE	HAZARD MODULE	VULNERABILITY MODULE	FINANCIAL MODULE

Agenda – Financial Model

Core Concepts

- Context
- Financial perspectives
- Secondary uncertainty
- The Event Loss Table (ELT)

Financial Model Processes

- Aggregation
- Using a loss distribution
- Calculating loss to financial layers

Statistics

- EP curves
- TCE curves
- AAL
- Standard deviation and CV

Interpreting Results

- Applications of modelling
- Return Period Loss
- Volatility
- Diversification

FINANCIAL MODULE

CORE CONCEPTS

Why Do We Need a Financial Module?

What does a peril model provide?

- Building coverage MDRs
- Uncertainty measure (CVs)
- *(& insured values from exposure data)*

What does a (re)insurer need?

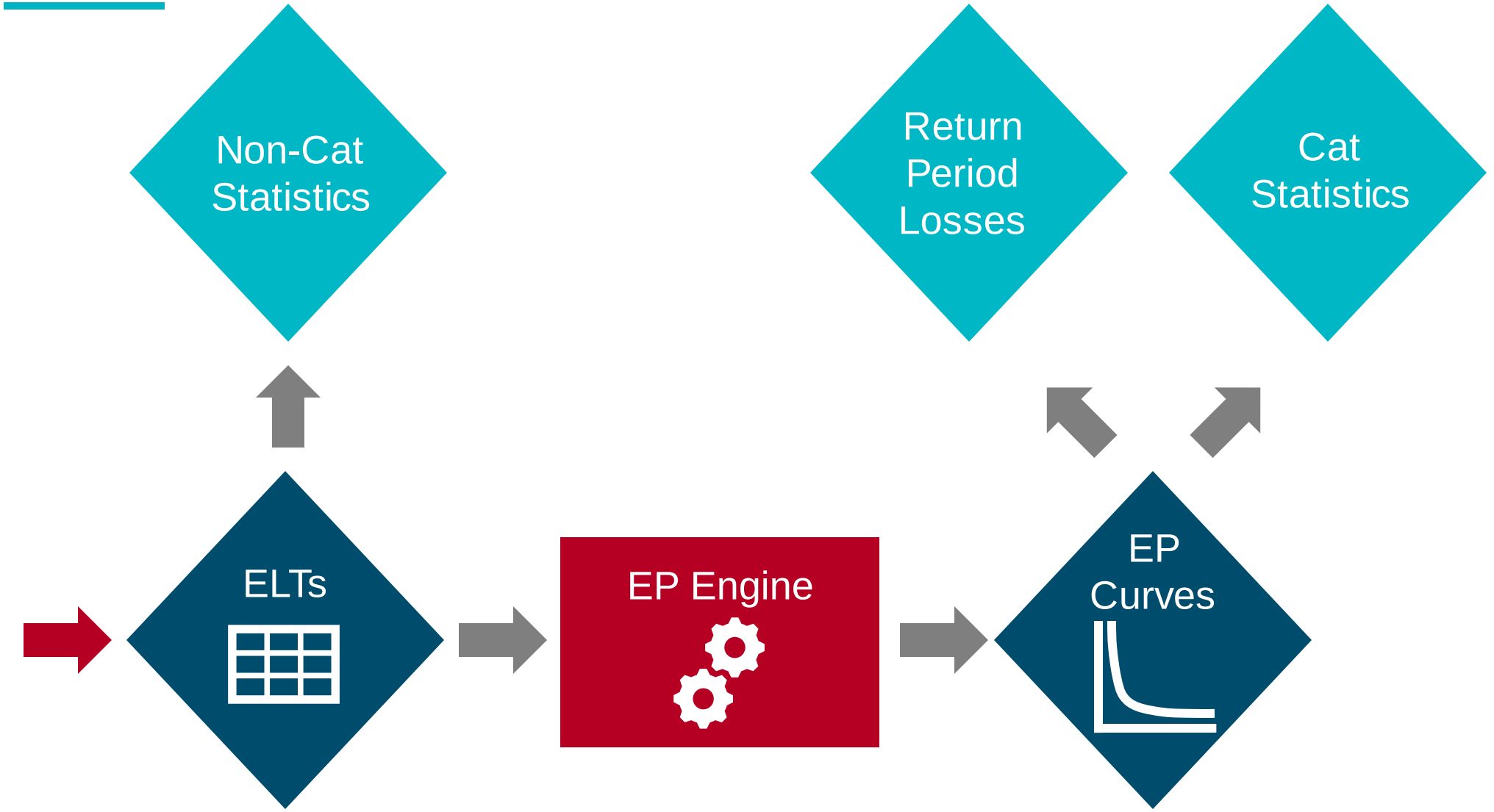
Monetary Loss

… to their portfolios

… to their primary contracts net of reinsurance [insurer]

… to their treaties net of retrocessions [reinsurer]

Financial Model Process Overview



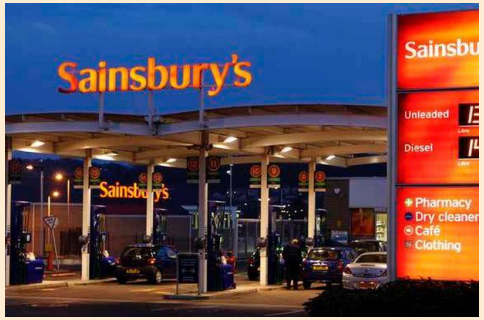
EXPOSURE LEVELS: LOCATION

- Address
- Primary Characteristics
- Coverage Values
  - *Building*
  - *Contents*
  - *BI*
- Coverage or Site Limits and Deductibles

EXPOSURE LEVELS: ACCOUNT

- Collection of locations
- Policies
  - *Limits & Deductibles*
  - *Sublimits or Special Conditions*
  - *Treaties*

Sainsbury's Account



EXPOSURE LEVELS: PORTFOLIO

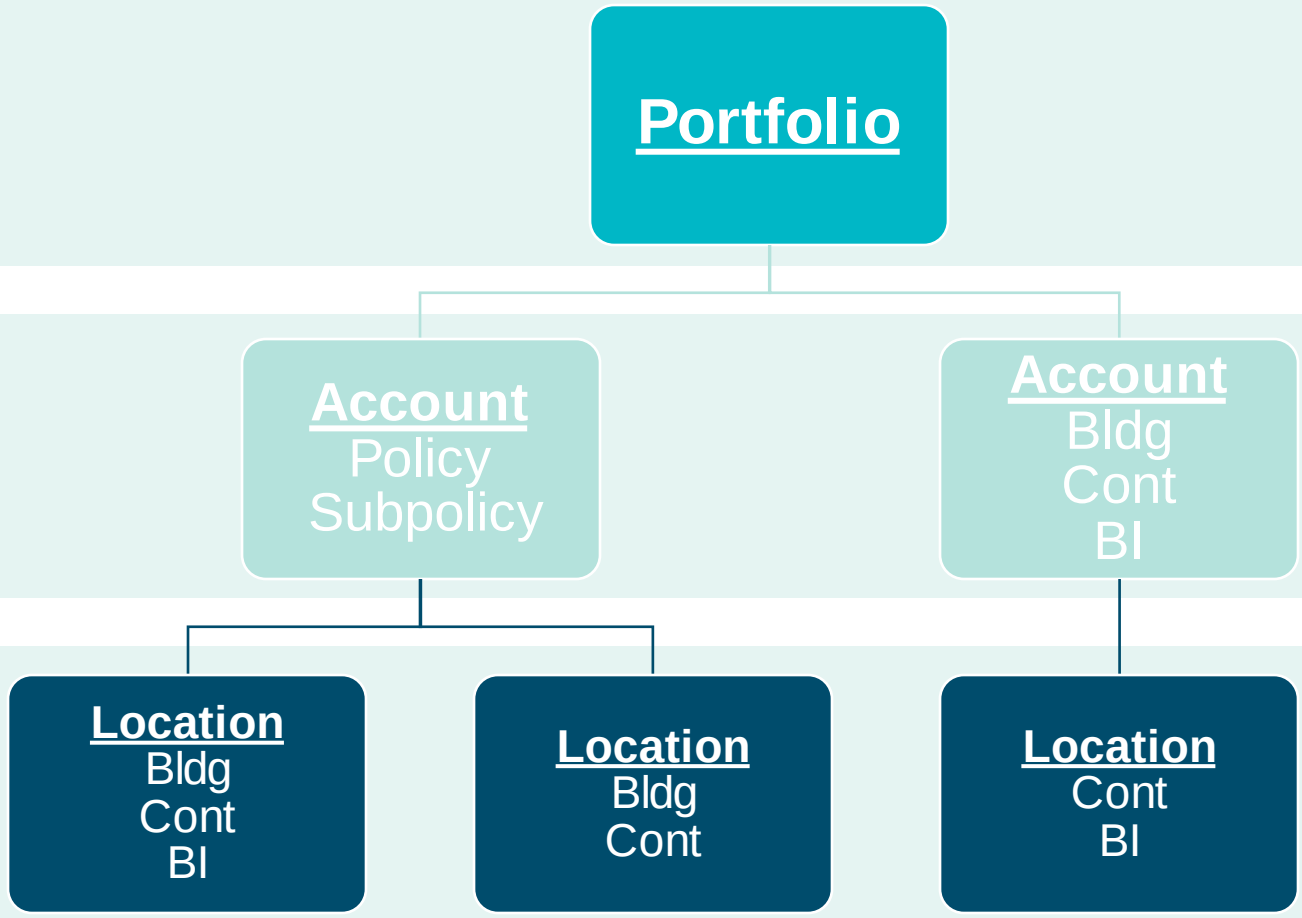
- Collection of accounts
- Company's book of business
- Catastrophe Treaties

Exposure Levels

Portfolio

Account
Policy
Policy Coverage
Subpolicy

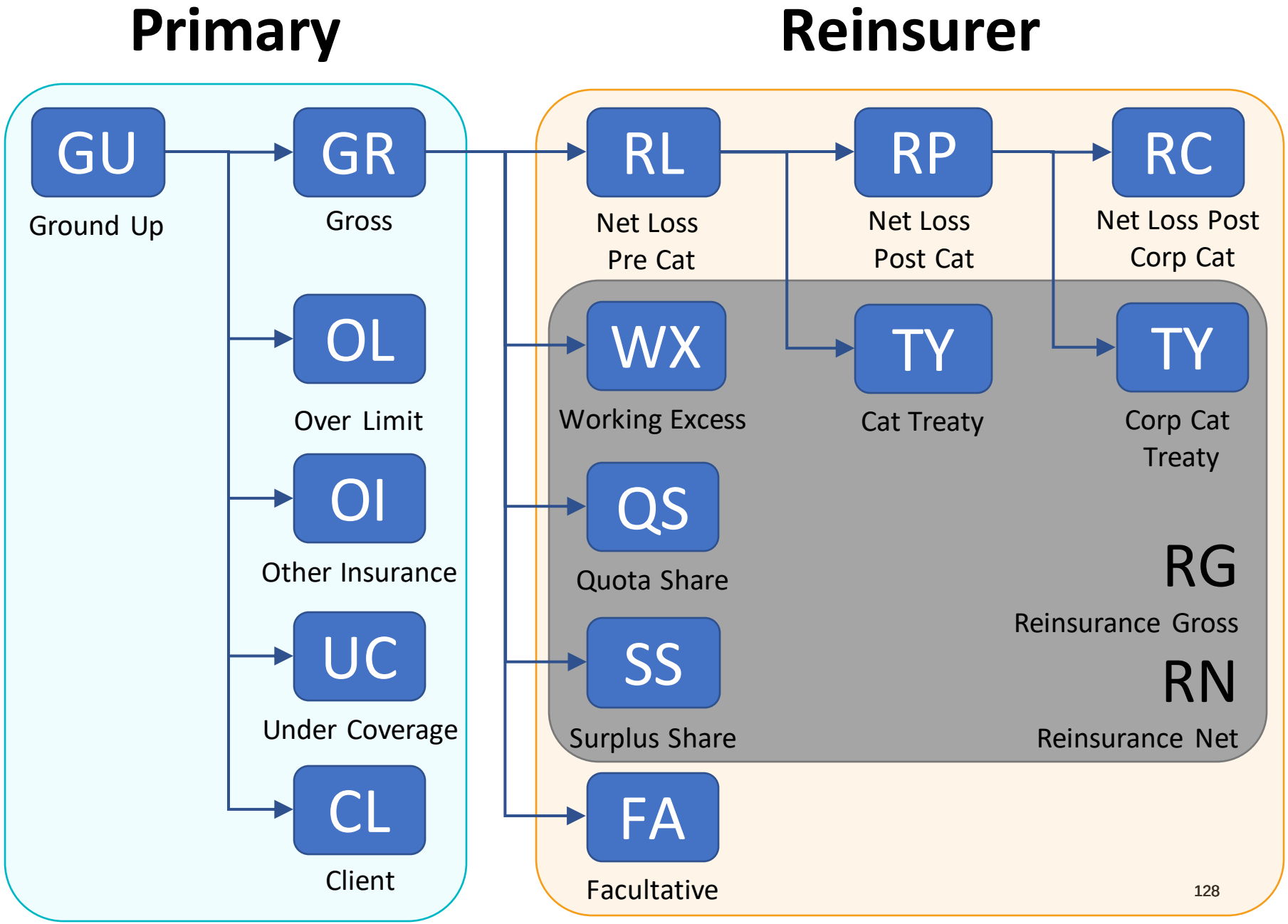
Location/Site
Location Coverage



FINANCIAL MODULE- CORE CONCEPTS

FINANCIAL PERSPECTIVES

Financial Perspectives



Financial Perspectives

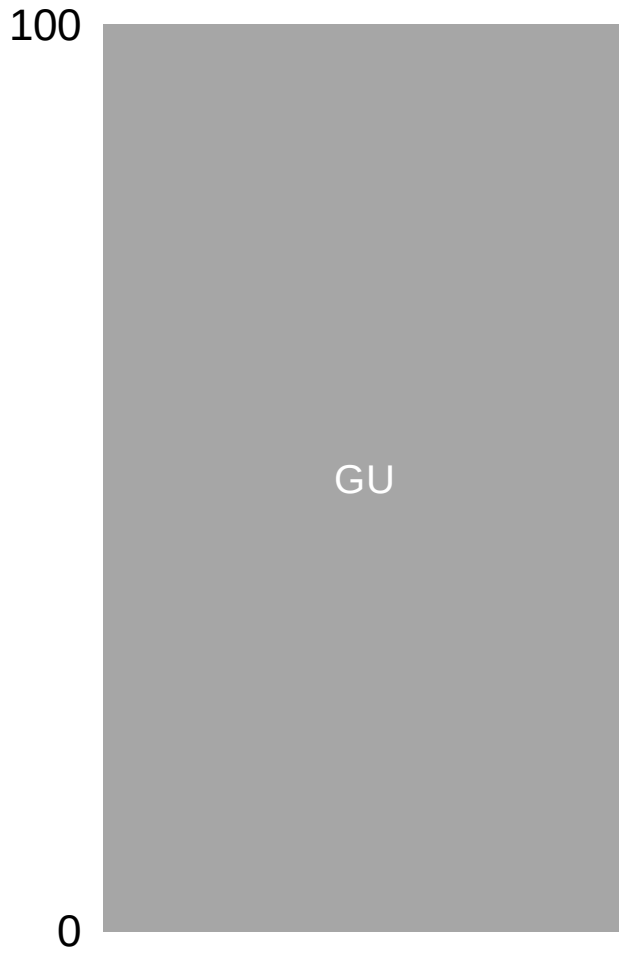
Example:

- 75% of 50m layer xs 15m policy
- 10m deductible
- 100m GU loss

1. Consider loss prior to layer application

GROUND UP LOSS

Total loss, irrespective of any (re)insurance structure



Financial Perspectives

Example:

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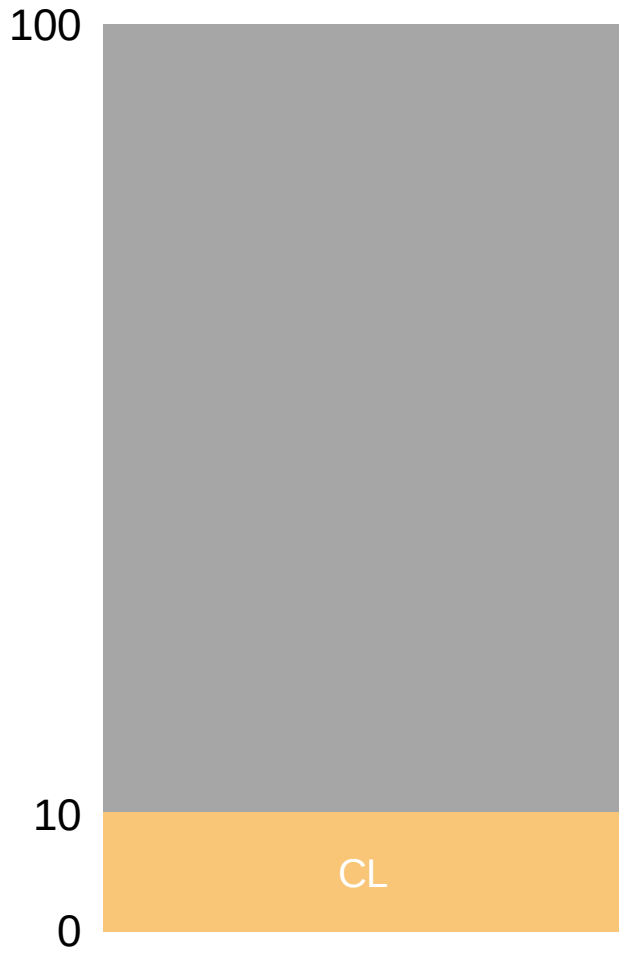
---

2. Consider the application of the deductible

CLIENT LOSS

Loss to the insured party, falling below the deductible



Financial Perspectives

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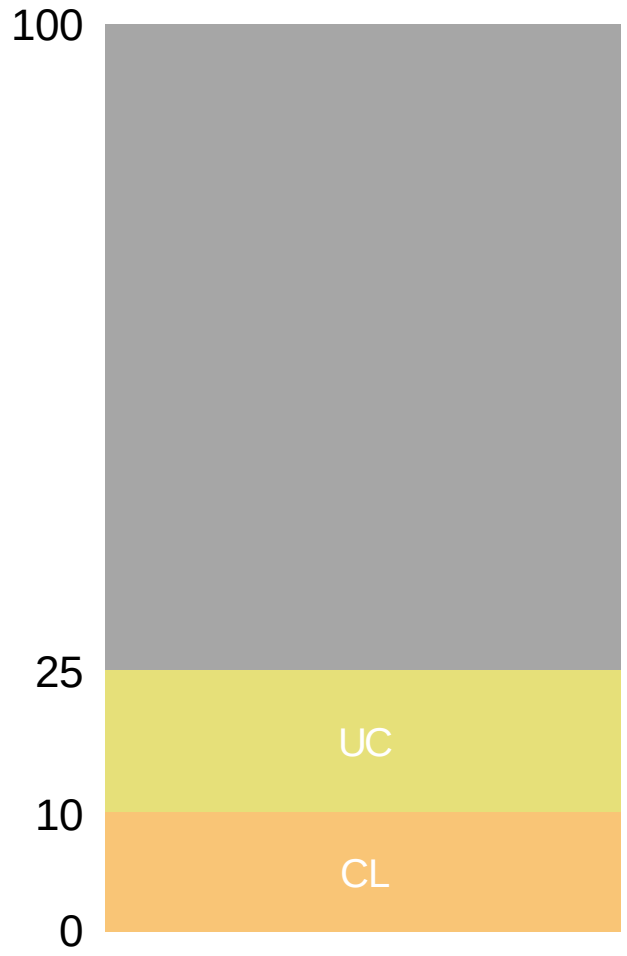
---

3. Consider the attachment point

UNDERLYING COVERAGE

Loss falling between the deductible and the policy inception



Financial Perspectives

Example:

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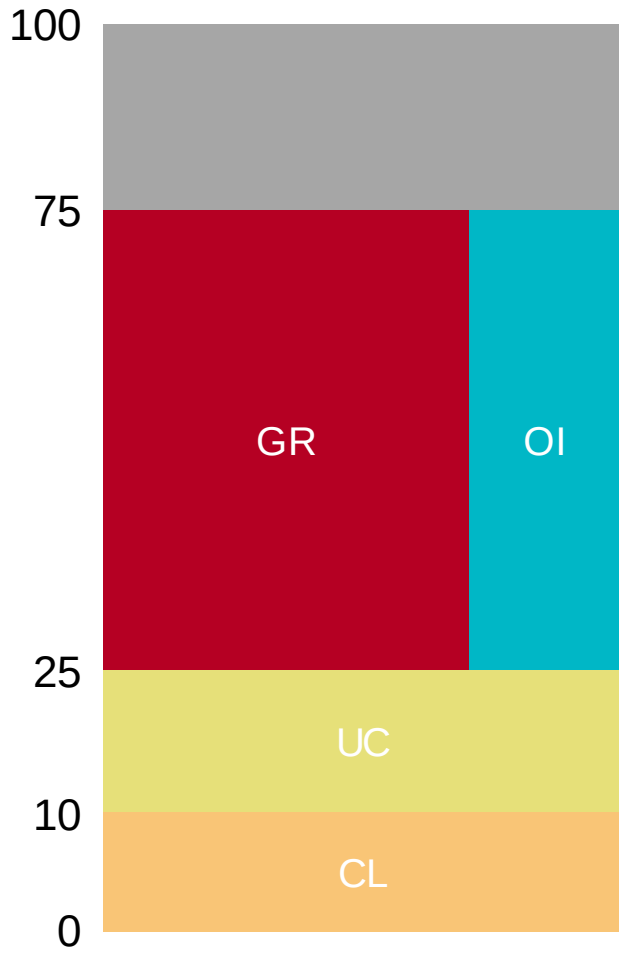
4. Consider the limit and participation

GROSS LOSS

Loss to the insurer, falling between policy inception and expiration accounting for participation



Financial Perspectives

Example:

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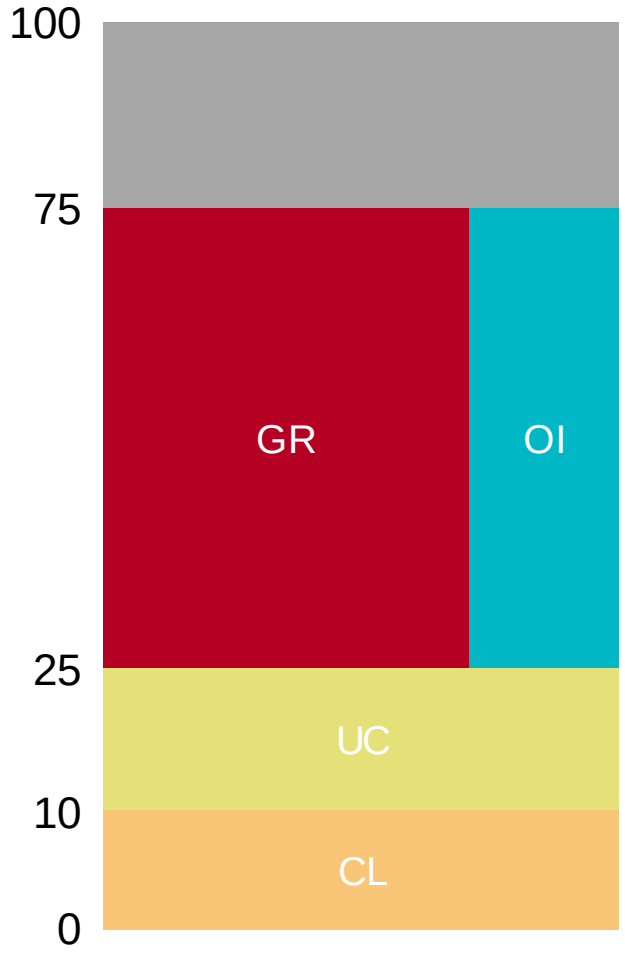
---

4. Consider the limit and participation

OTHER INSURER LOSS

Loss adjacent to policy layer, assumed to be covered by another insurer



Financial Perspectives

Example:

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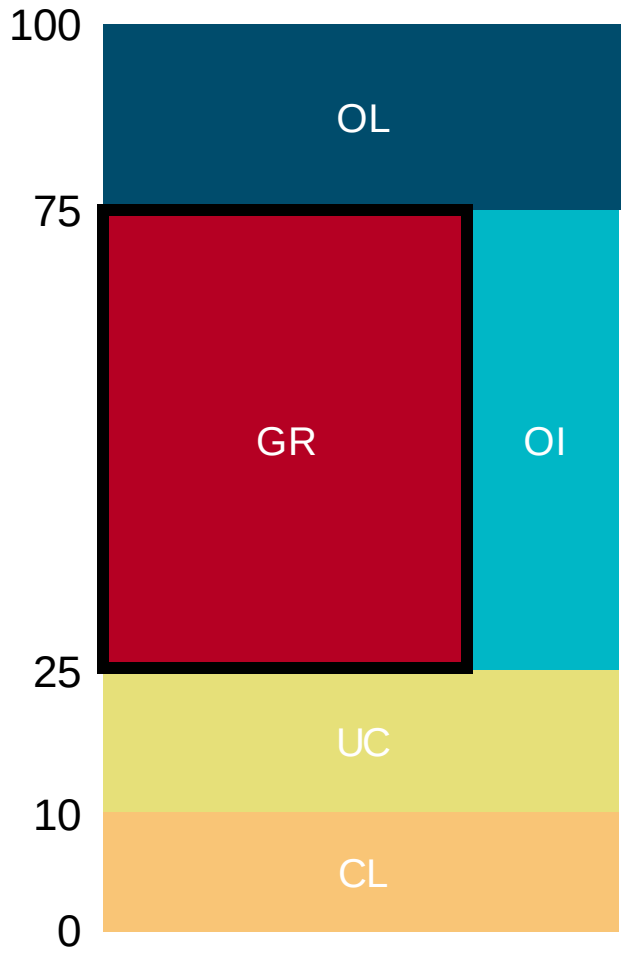
---

5. Consider loss above the limit

OVER LIMIT LOSS

Loss above the policy limit up to the total GU loss



Financial Perspectives

Example:

- Apply per risk treaties
- Apply CAT treaties

6. Consider loss to and net of per risk reinsurance

FA, SS, QS, WX

Loss to each per risk treaty type

NET LOSS PRE CAT

GR loss net of per risk reinsurance recoveries

Per Risk Reinsurance

FACULTATIVE

- Applies to either an individual policy or an individual location
- Designed to cede away a portion of a specific individual risk

SURPLUS SHARE

- Terms specific to individual risks
- Multiple risks can be covered under the treaty with an overarching occurrence limit

QUOTA SHARE

- Applies to all risks in portfolio that meet specific user-defined criteria
- Per risk terms are identical on each risk
- All risks covered with additional occurrence limit

WORKING EXCESS

- Applies exactly as QS

Financial Perspectives

Example:

- Apply per risk treaties
- Apply CAT treaties

7. Consider loss to and net of CAT treaties

Cat TYs

Loss to each cat treaty

NET LOSS POST CAT

RL loss net of CAT treaties

Portfolio Reinsurance Types

PORTFOLIO

- Catastrophe
- Corporate catastrophe → group-level treaties when underlying analyses have their own CAT treaties coded.
- *(stop loss) → Apply directly onto the AEP curve*

Financial Perspectives

Example:

- Apply per risk treaties
- Apply CAT treaties

---

8. Consider loss to all non-fac reinsurance

REINSURANCE GROSS

Loss to all treaty reinsurance accounting for %share

REINSURANCE NET

Reinsurance gross loss reduced by %retention

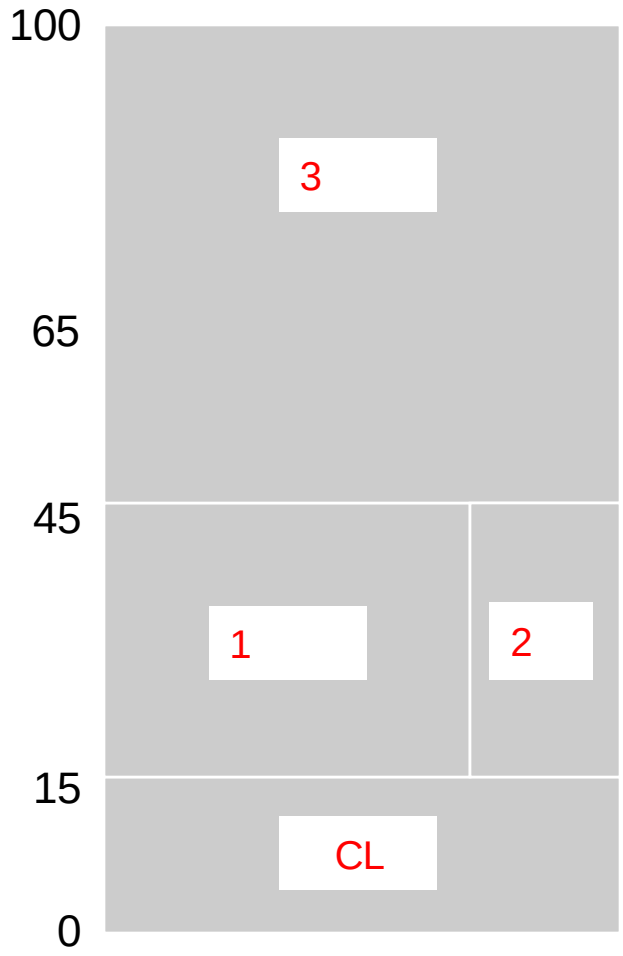
Exercise

Complete the box diagram for the new financial terms

Financial Perspectives

Label the financial perspectives

- 70% of 30m layer
- 15m deductible
- 100m GU loss



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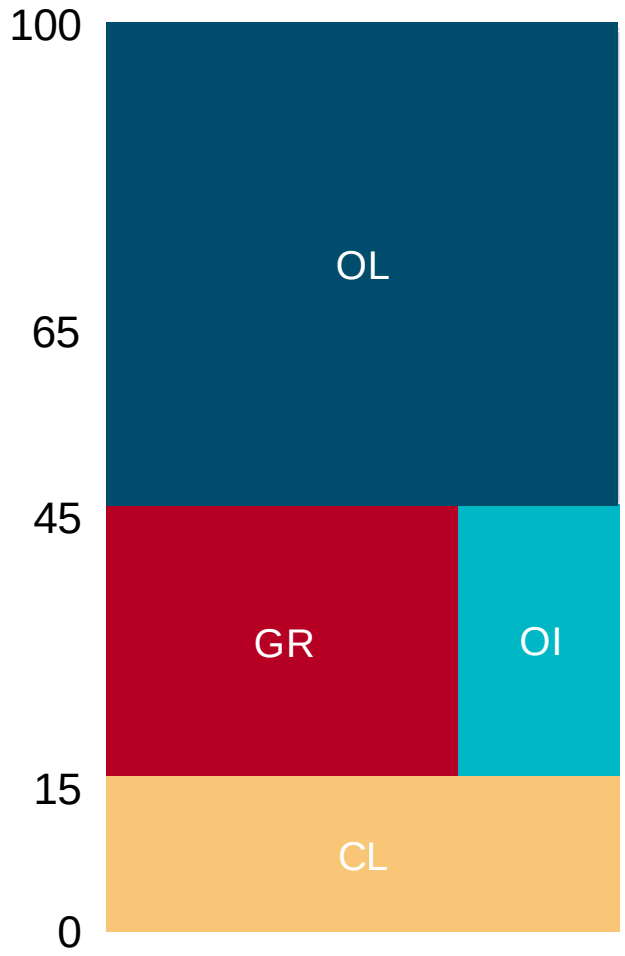


Consider the limit and participation

FINANCIAL MODULE – CORE CONCEPTS

SECONDARY UNCERTAINTY

Modelled Uncertainty

Primary Uncertainty

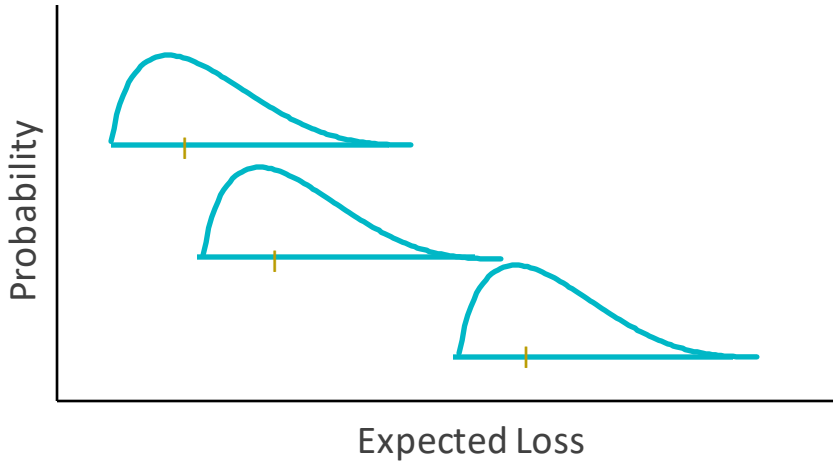
- The uncertainty of which event, if any, will occur
- The uncertainty in the size of the event as measured by the mean loss

Secondary Uncertainty

The uncertainty in the amount of loss, given that a specific event has occurred

Three sources of secondary uncertainty:

1) Hazard
2) Vulnerability
3) Exposure data



The Event Loss Table (ELT)

EventID	Rate	Financial Perspective	Mean Loss	StdDevC	StdDevI	Exposure
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469282	0.0002	GU	211,863	111,154	27,789	10,593,150
469293	0.0123	GU	207,009	109,865	27,466	10,350,450
469266	0.0004	GU	196,299	106,726	26,681	9,814,950
469283	0.0439	GU	137,409	74,708	18,677	6,870,465

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469283	0.0439	GU	137,409	74,708	18,677	6,870,465

Mean Loss
The expected amount of loss to this exposure from a given event

Remember…

ELTs exist at different *exposure levels* (loccvg, site, account, portfolio,…)
ELTs exist at different *financial perspectives* (GU, GR, RL, RG,…)

The Event Loss Table (ELT)

Event ID
A unique identifier assigned to each event during stochastic event generation

Event Rate
Annual probability of occurrence assigned to the event

Financial Perspective
Indicates which financial structures have been considered

EventID	Rate	Financial Perspective	Mean Loss	StdDevC	StdDevI	Exposure
469292	0.0029	GU	226,945	114,932	28,733	11,347,250
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Mean Loss
The expected amount of loss to this exposure from a given event

Standard Deviation
The measure of uncertainty around the mean loss, representing the potential range of loss

Why two?

RiskLink splits the standard deviation into an independent and a correlated piece. More detail on this later….

The Event Loss Table (ELT)

Event ID
A unique identifier assigned to each event during stochastic event generation

Event Rate
Annual probability of occurrence assigned to the event

Financial Perspective
Indicates which financial structures have been considered

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Mean Loss
The expected amount of loss to this exposure from a given event

Standard Deviation
The measure of uncertainty around the mean loss, representing the potential range of loss

Exposure value
The total amount at risk to the event for the given exposure level and financial perspective

Remember…

Financial perspective is important in understanding what the Exposure Value represents.

The Event Loss Table (ELT)

EventID	Rate	Financial Perspective	Mean Loss	StdDevC	StdDevI	Exposure
469292	0.0029	GU	226,945	114,932	28,733	11,347,250
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Primary Uncertainty (frequency)
The uncertainty in the likelihood of event occurrence and size as measured by the mean loss

The Event Loss Table (ELT)

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469283	0.0439	GU	137,409	74,708	18,677	6,870,465

Primary Uncertainty (frequency)
The uncertainty in the likelihood of event occurrence and size as measured by the mean loss

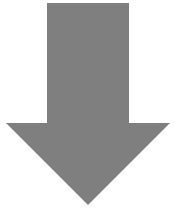
Secondary Uncertainty (severity)
The uncertainty in the amount of loss, given an event has occurred. There are three sources of secondary uncertainty:

1. Hazard
2. Vulnerability
3. Exposure data

FINANCIAL MODULE

MODEL PROCESSES

Financial Model Process Overview



Input: GU loccvg level ELTs

TASK 1

Aggregate ELTs from loccvg level up to higher exposure levels (location, policy, account, portfolio) using correlation assumptions

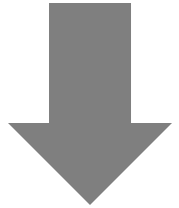
TASK 2

Fit a **probability distribution** (Beta distribution) to model the severity of each individual event ground up loss

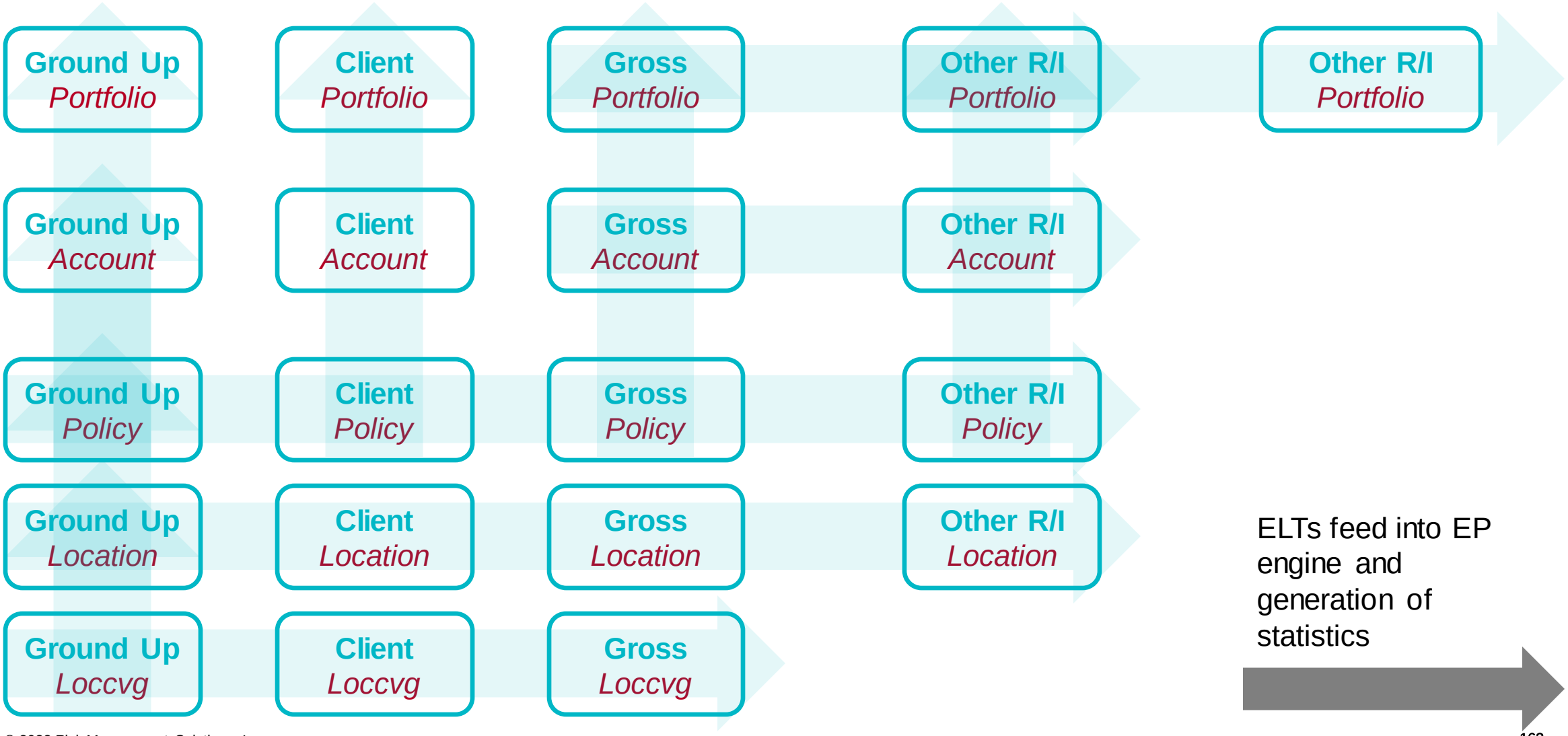
TASK 3

Apply insurance and reinsurance structures to generate ELTs for non-GU financial perspectives

Output: ELTs at all aggregation levels for all financial perspectives



Financial Model Process Overview



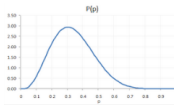
TASK 1: Aggregation

TASK 2: Beta Distribution

TASK 3: Layer Calculations

Model Input

MDRs



CVs

Exposure Values

Ground Up
Loccvg

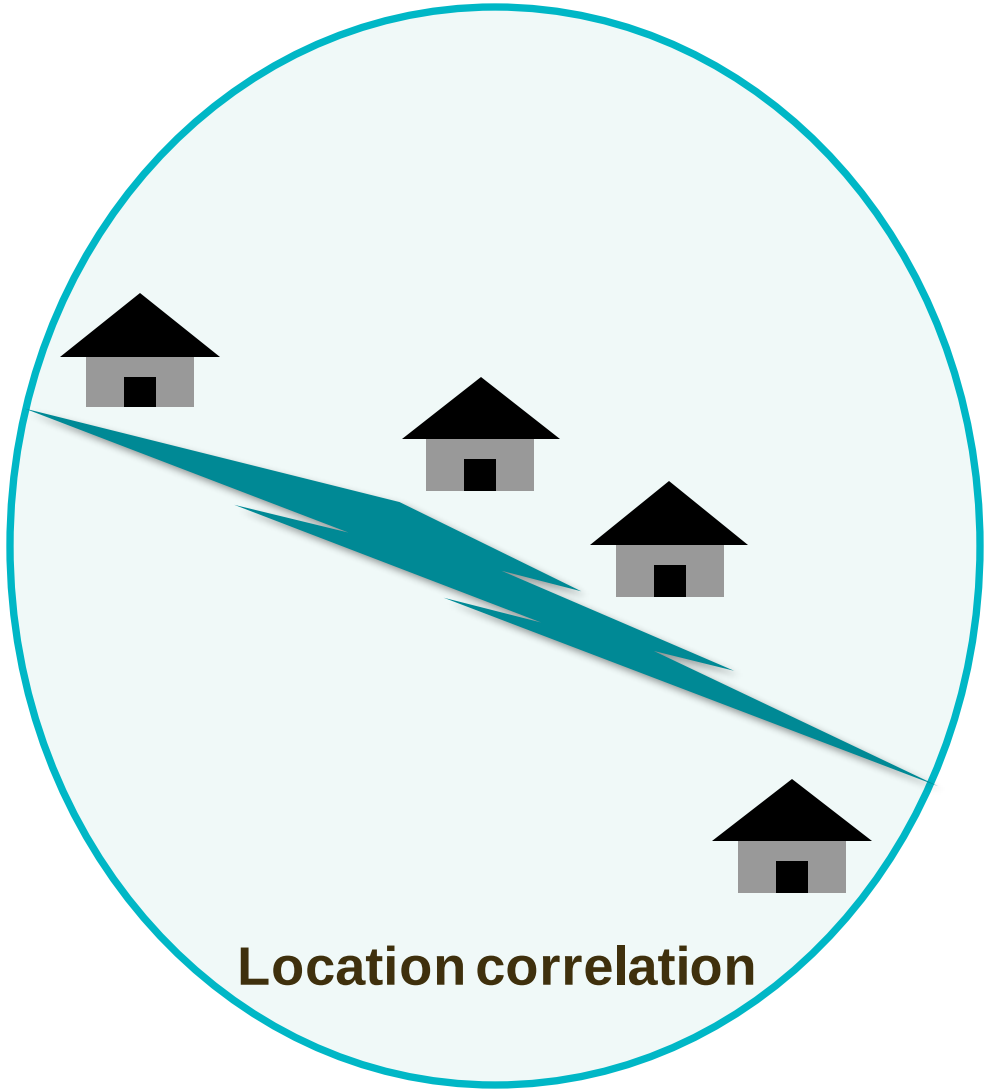
	Mean Loss (from MDR)	Standard Deviation (from CV)	Exposure Value
Event 1			
Event 2			
…			

Aggregation

loccvg	Mean Loss	Standard Deviation	Exposure Value
Building	55	85	600
Contents	30	45	200
BI	15	20	200
location			
Loc1	=SUM()	=?	=SUM()

- Aggregation of mean losses and exposure values is simple
- Aggregation of standard deviations requires more thought

Correlation in Catastrophe Models



Aggregation of Standard Deviations

Aggregation with **100% correlation** assumption

loccvg	Standard Deviation
Building	85
Contents	45
BI	20
location	
Loc1	=SUM() = 150

Loccvg → location

Policy → account

Aggregation with **100% independence** assumption

	Standard Deviation
	85
	45
	20
	=SQRTSUMSQ() = 98.23

Not used

Aggregation with **partial correlation** assumption

location	Standard Deviation
Loc1	85
Loc2	45
Loc3	20
Policy	
PolA	=ω x SUM() + (1-ω) x SQRTSUMSQ()

All other aggregation (at GU)

Splitting the Standard Deviation

Aggregation with **partial correlation** assumption

Let:

$$\sigma = \sigma_I + \sigma_C$$

where:

$$\sigma_c = \omega\sigma$$

$$\sigma_I = (1 - \omega)\sigma$$

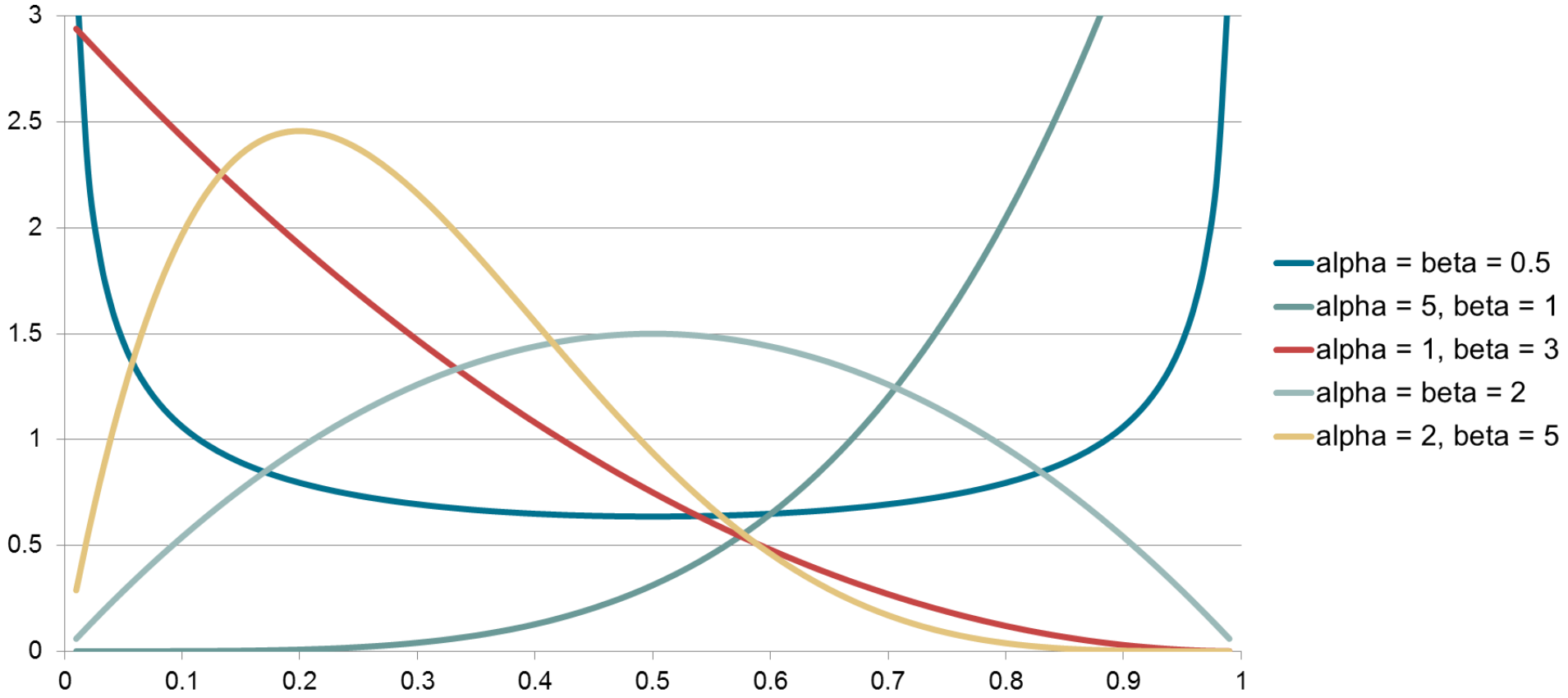
… define a correlation weight ω to split the standard deviation into independent and correlated pieces

TASK 1: Aggregation

TASK 2: Beta Distribution

TASK 3: Layer Calculations

Choice of Beta Distribution



Parametrising the Beta Distribution

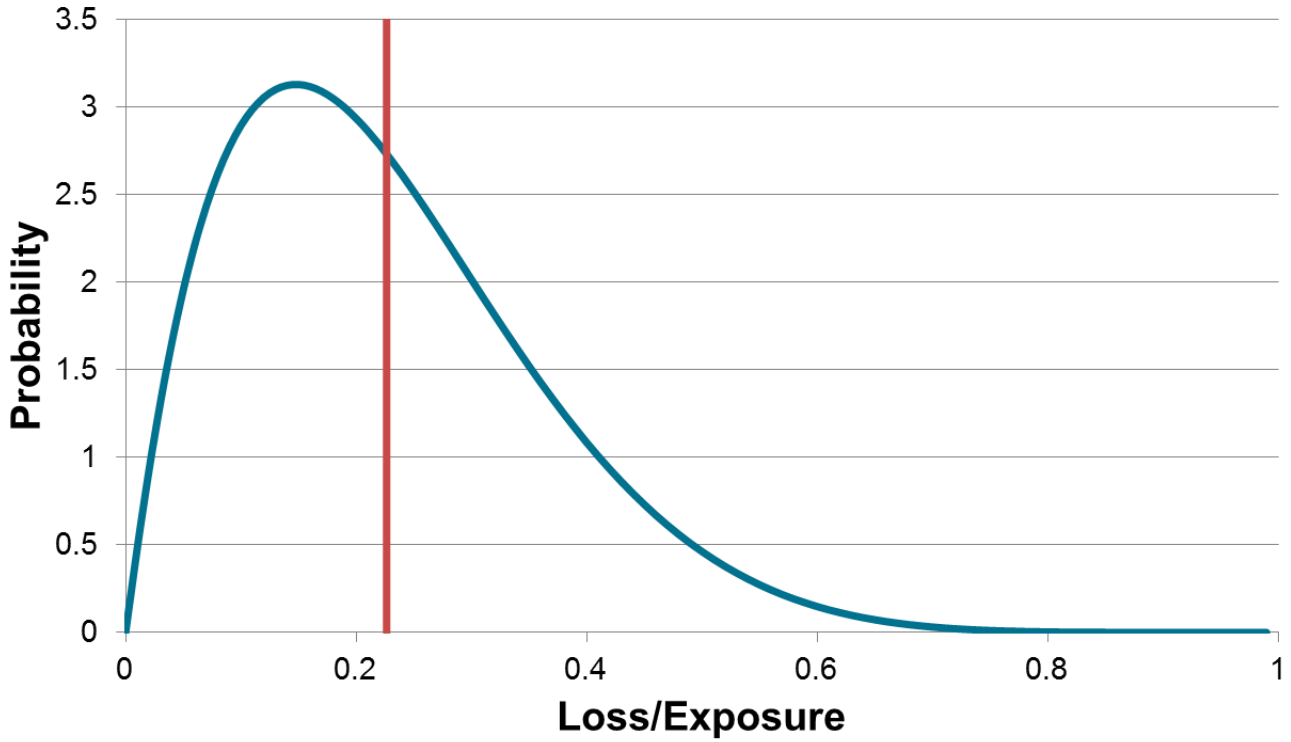
EventID	Rate	Loss	Std. Dev	Exposure	Mean (μ)	CV	α	β
1	2.08E-06	36,250.19	21,207.32	160,000.00	0.226564	0.585026	2.03	6.94

$$\mu = \frac{Loss}{Exposure}$$

$$CV = \frac{Std.Dev}{Loss}$$

$$\alpha = \frac{1-\mu}{CV^2} - \mu$$

$$\beta = \frac{\alpha(1-\mu)}{\mu}$$



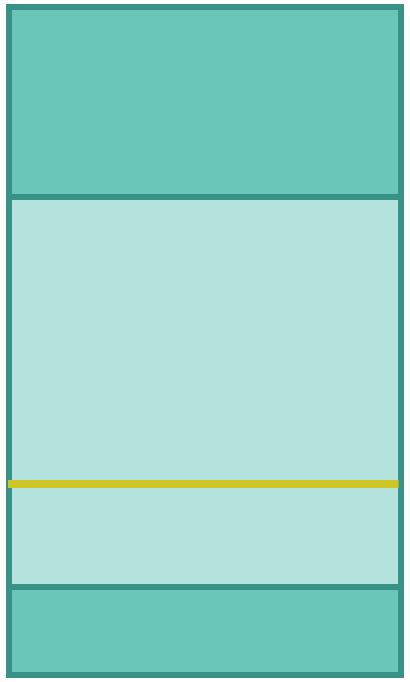
TASK 1: Aggregation

TASK 2: Beta Distribution

TASK 3: Layer Calculations

Impact of Secondary Uncertainty

Loss without Secondary Uncertainty

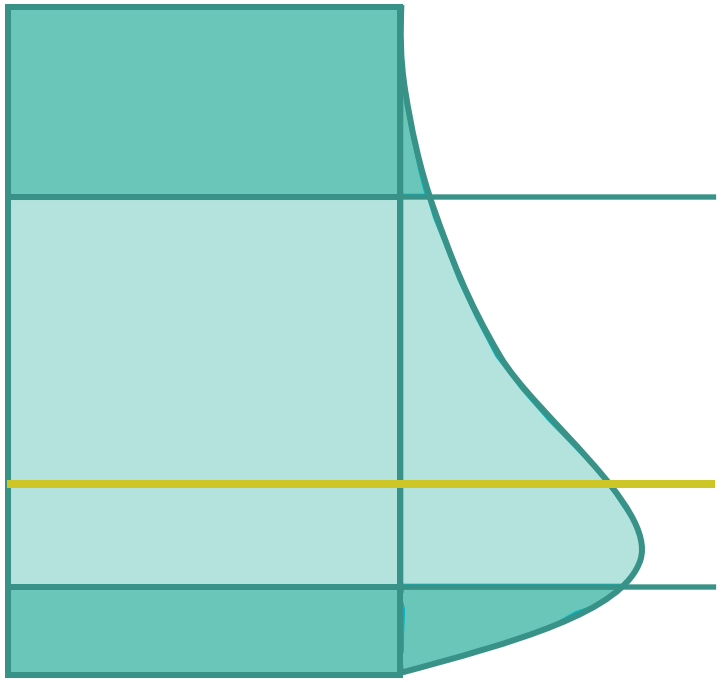


0% chance of GR = limit

100% chance of GR = GU - ded

100% chance of full deductible recovery

Loss with Secondary Uncertainty



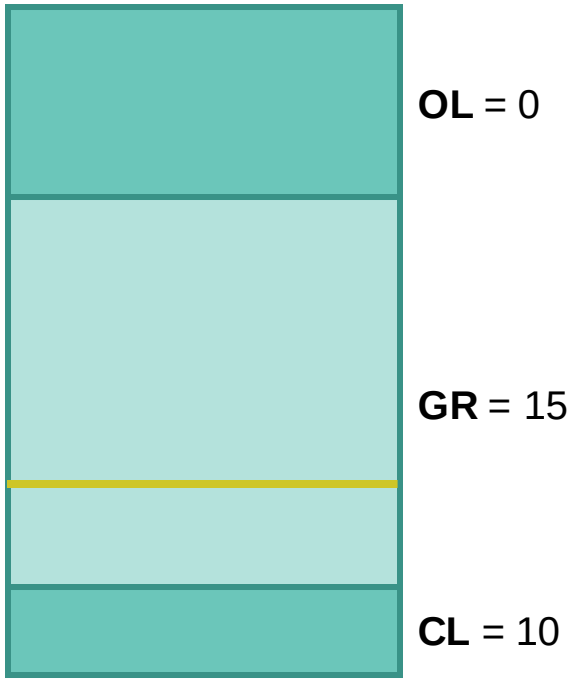
Non-zero chance of full insurance recovery

Non-zero chance of partial insurance recovery

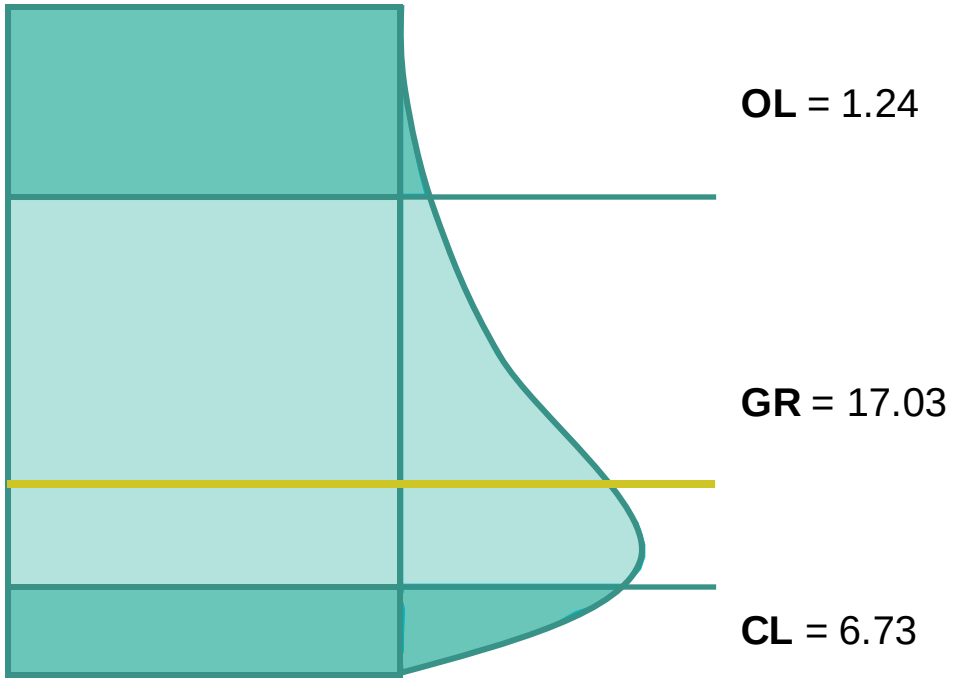
Non-zero chance of no insurance recovery

Impact of Secondary Uncertainty

Loss without Secondary Uncertainty



Loss with Secondary Uncertainty



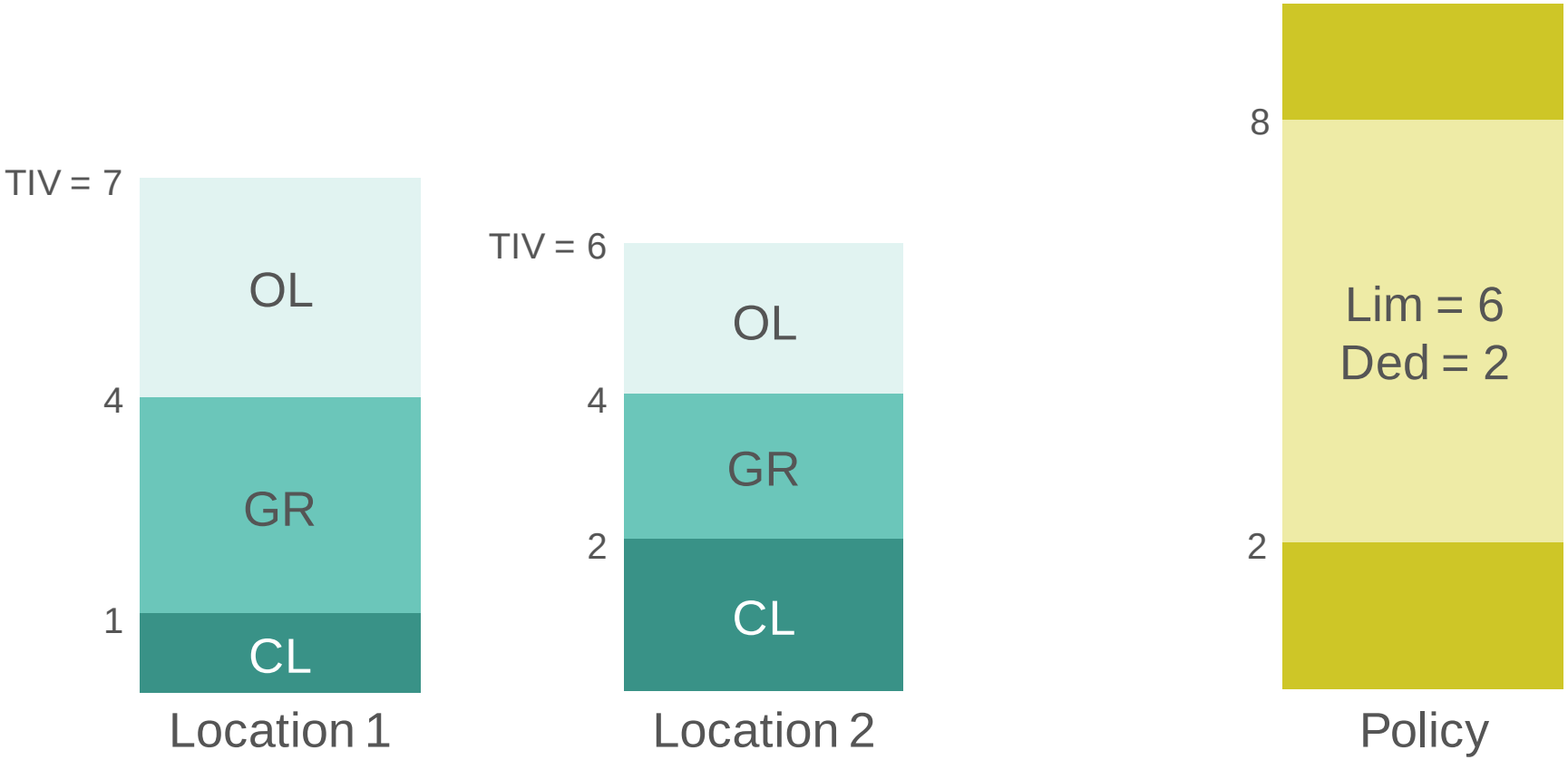
Ground up loss = 25, Deductible = 10

Coding Insurance Financial Terms

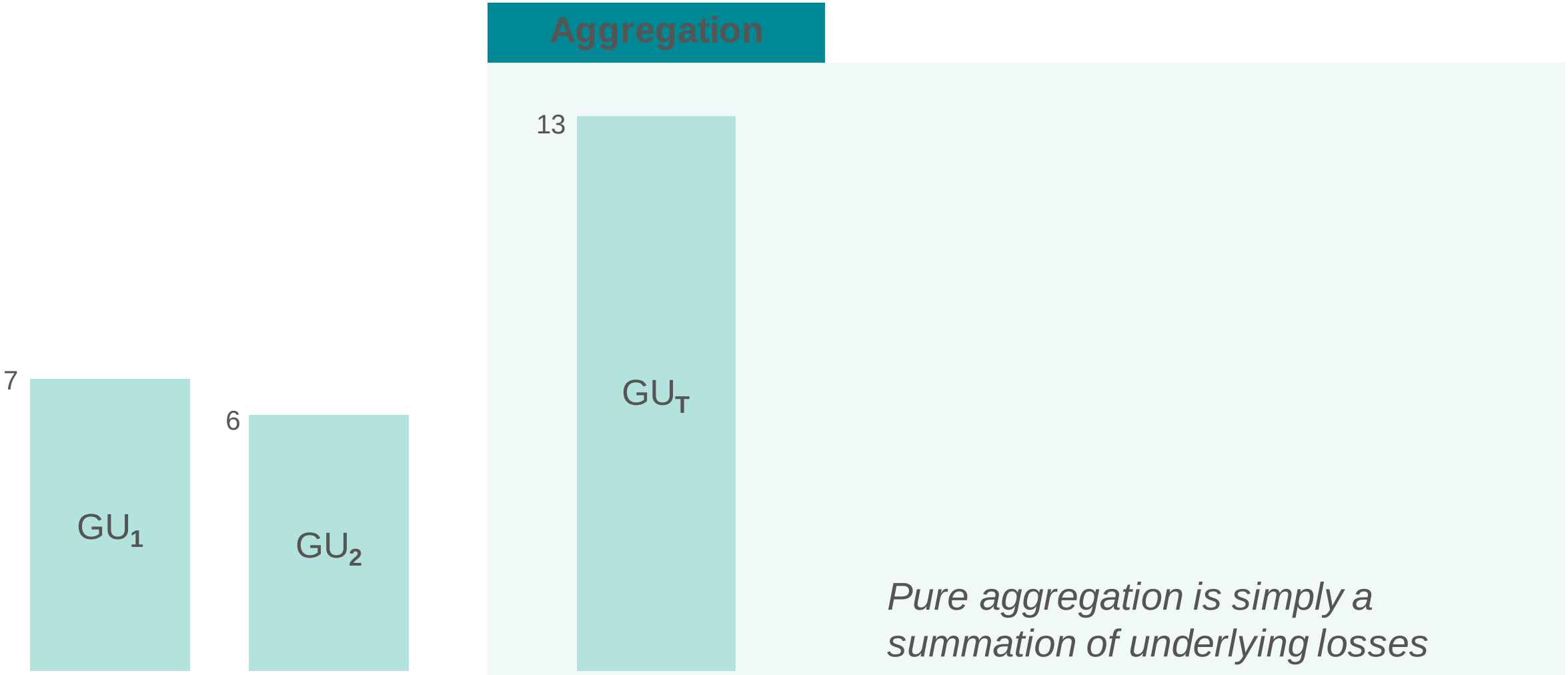
Insurance						
	Limit	Ded	MinDed	MaxDed	ExcessOf	PartOf
Portfolio						
Account						
Policy	✓	✓	✓	✓	✓	✓
Subpolicy	✓	✓				
Polcvg	✓	✓				
Site	✓	✓				
Loccvg	✓	✓				

- *No insurance terms at account or portfolio levels*
- *Basic limits and deductibles only at all non-policy levels*
- *All deductibles can be coded as either value or percentage*

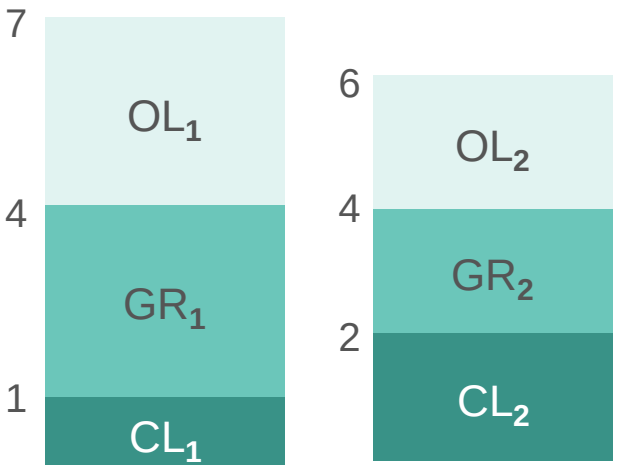
Example: Simple Gross Accumulation



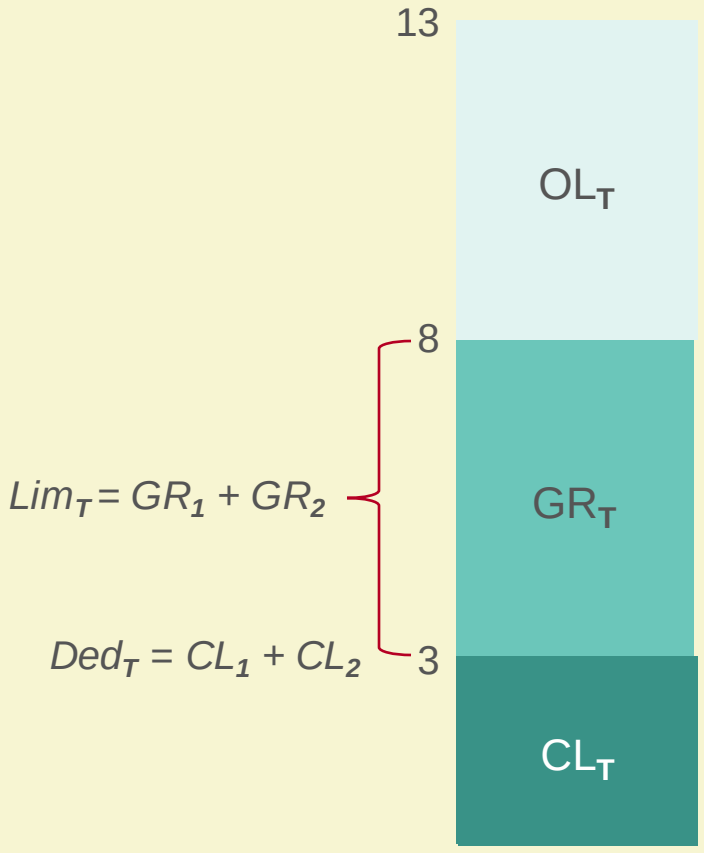
Example: Simple Gross Accumulation



Example: Simple Gross Accumulation

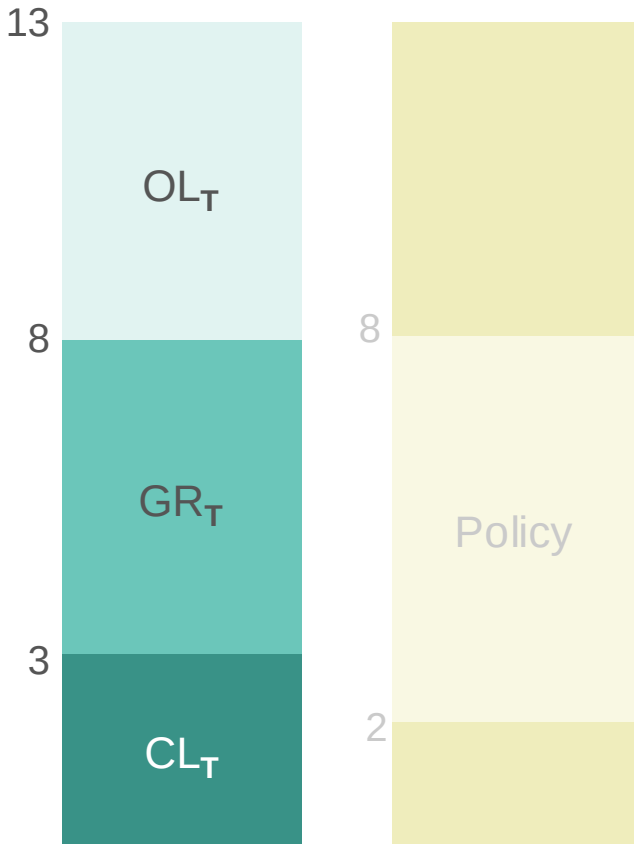


Aggregation | **Translation**



Translation of loss defines the translated policy terms

Example: Simple Gross Accumulation



Aggregation | **Translation** | **Comparison**

Compare the translated limit with the coded limit…

*Choose the **smallest***

Compare the translated deductible with the coded deductible…

*Choose the **largest***

Example: Simple Gross Accumulation

Aggregation | **Translation** | **Comparison**

Compare the translated limit with the coded limit…

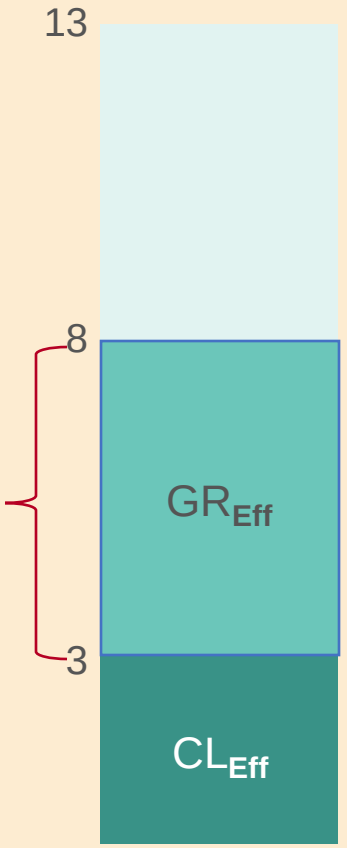
*Choose the **smallest***

$Lim_{Eff} = min(Lim_T , Lim_C)$

Compare the translated deductible with the coded deductible…

$Ded_{Eff} = max(Ded_T , Ded_C)$

*Choose the **largest***



Summary

Aggregation	Translation	Comparison
Sum GU losses across locations	Sum CL, GR losses across locations	Compare translated terms with coded terms
Find total GU loss	**Find translated limit and deductible**	**Minimise GR loss**

…Remember these are accumulations, not standard distributed losses

FINANCIAL MODULE

STATISTICS

The Event Loss Table (ELT)

EventID	Rate	Financial Perspective	Mean Loss	StdDevC	StdDevI	Exposure
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Consider the follow financial terms:
Deductible = 20,000
Limit = 280,000

The Event Loss Table (ELT)

EventID	Rate	Financial Perspective	Mean Loss	StdDevC	StdDevI	Exposure
469292	0.0029	GR	175,468	69,683	17,421	280,000
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469266	0.0004	GR	154,814	71,743	17,936	280,000
469283	0.0439	GR	112,874	63,996	15,999	280,000

Consider the follow financial terms:
Deductible = 20,000
Limit = 280,000

DLM financial model calculates loss to this layer for **each event**, considering secondary uncertainty, to arrive at a gross loss (GR) ELT

Non-EP Statistics

EventID	Rate	Financial Perspective	Mean Loss	StdDevC	StdDevI	Exposure
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Average Annual Loss (AAL)
The expected amount of loss from all events in a year. It is the annual **pure premium** required to cover **modeled** loss over time

To calculate AAL from the ELT for a given financial perspective, take the sum product of the event rate and mean loss:

$$\sum_{i=1}^{N} L_i \times r_i$$

Alternatively….

The AAL can be calculated from the area under the aggregate exceedance probability (AEP) curve. More on this later….

Non-EP Statistics

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Annual Standard Deviation
The measure of uncertainty around the AAL.

Not to be confused with the event standard deviation.

Incorporates both primary and secondary uncertainty.

$$StDev = \sqrt{\sum_{i=1}^{N} L_i^2 \times r_i \times (1 + cv_i^2)}$$

Where:

L_i = mean loss for event i
r_i = annual rate for event i
cv_i = CV for event i (stdev/mean loss)
N = number of events

Non-EP Statistics

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Primary Uncertainty (frequency)
The uncertainty in the likelihood of event occurrence

Secondary Uncertainty (severity)
The uncertainty in the amount of loss, given an event has occurred.

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Not to be confused with the event standard deviation.

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Not to be confused with the event standard deviation.

Incorporates both primary and secondary uncertainty.

$$StDev = \sqrt{\sum_{i=1}^{N} L_i^2 \times r_i \times (1 + cv_i^2)}$$

Coefficient of Variation (CV)
Standard deviation normalized by the AAL to provide a comparative metric showing uncertainty relative to loss

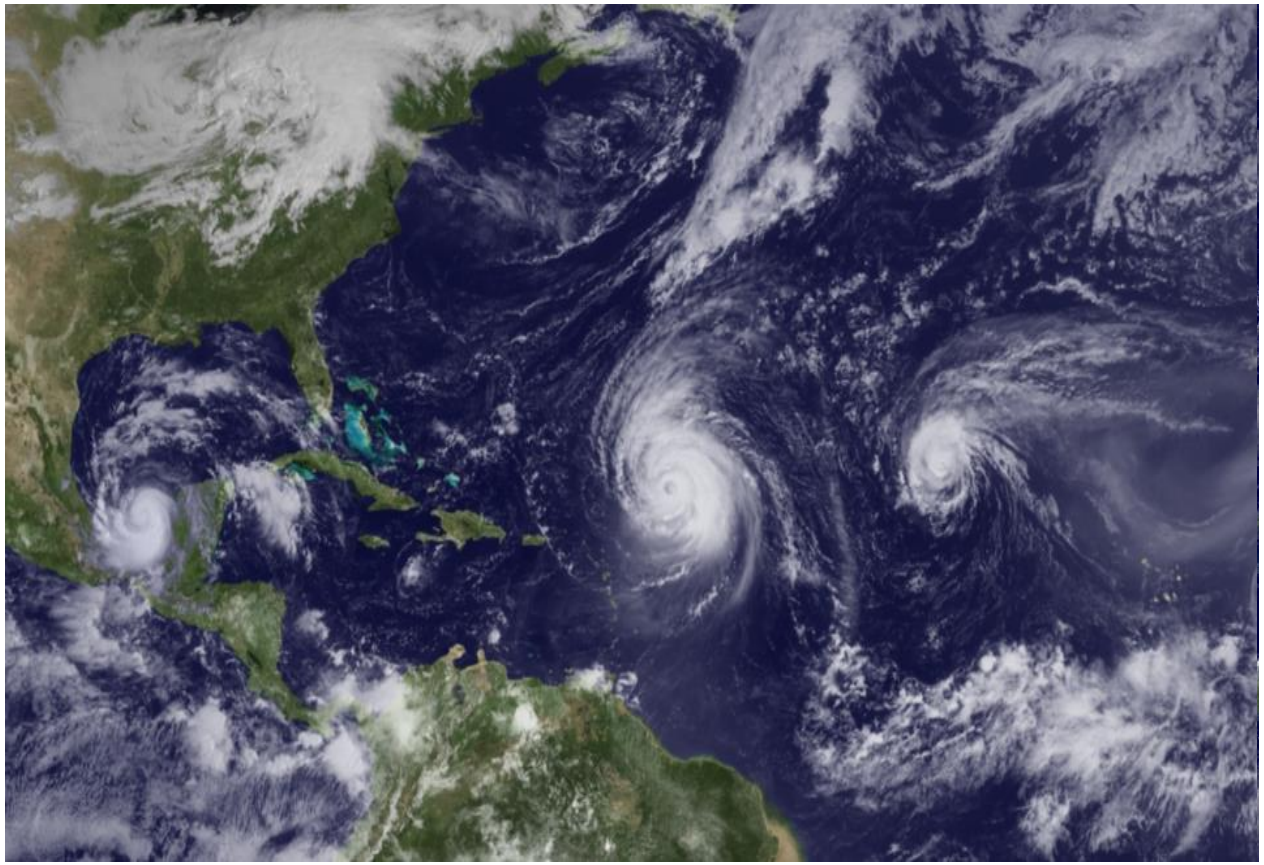
$$CV = \frac{StdDev}{AAL}$$

What is Exceedance Probability?

Exceedance Probability

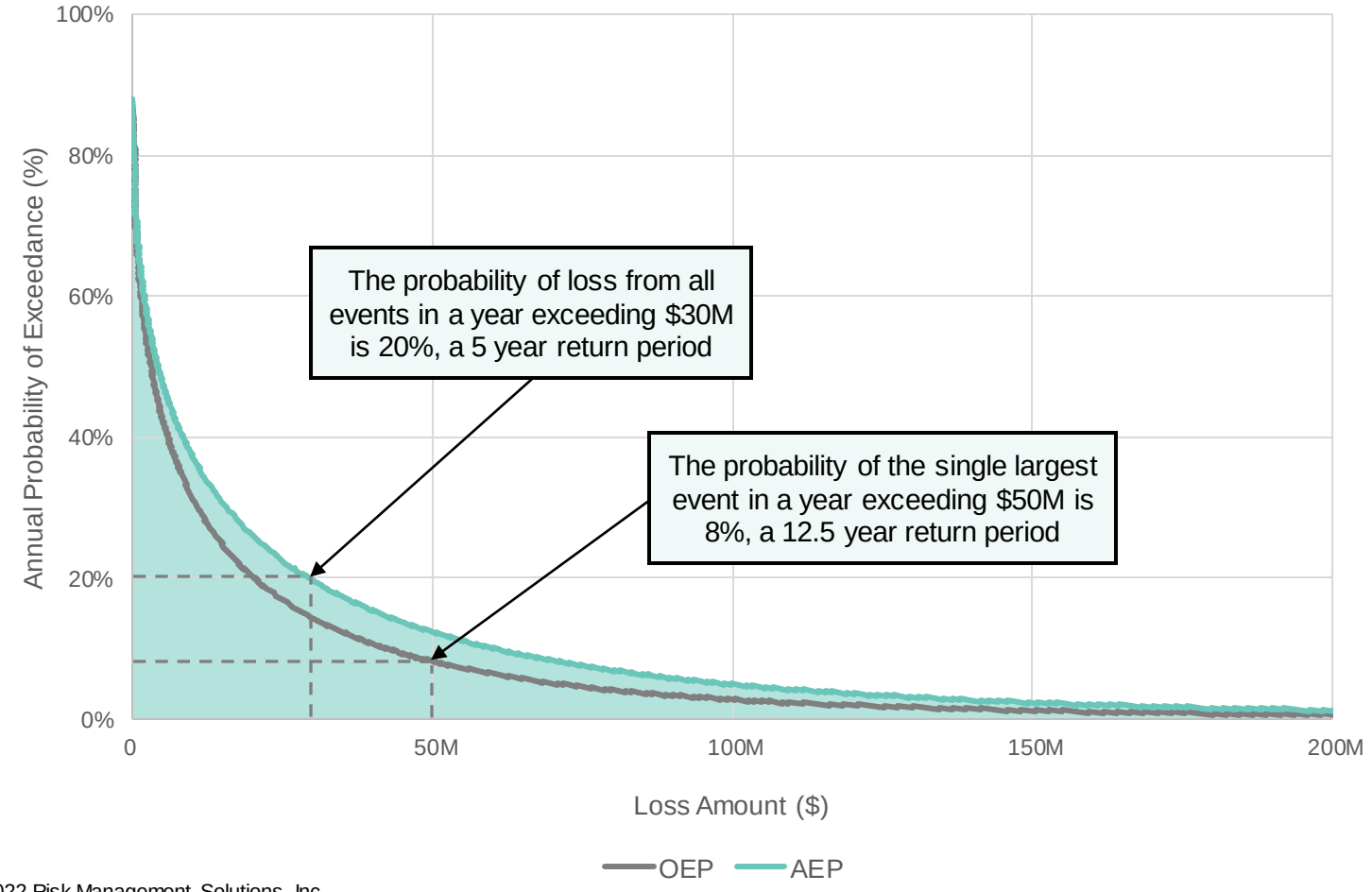
Occurrence Exceedance Probability (OEP) *is the probability that losses from the* ***single largest occurrence*** *in a year will exceed a given threshold.*

Aggregate Exceedance Probability (AEP) *is the probability that losses from* ***all occurrences*** *in a year will exceed a given threshold.*



Exceedance Probability

Interpretation



Reminder: Average Annual Loss (AAL)
The expected amount of loss from all events in a year. It is the annual **pure premium** required to cover **modeled** loss over time

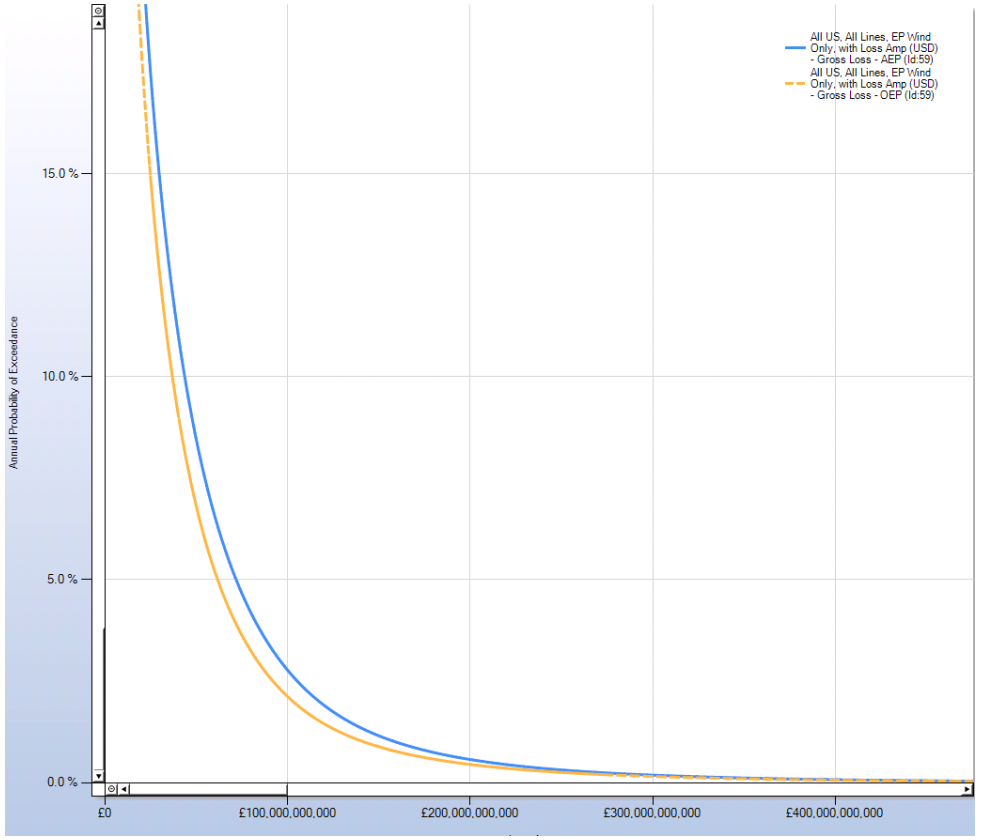
To calculate AAL from the ELT for a given financial perspective, take the sum product of the event rate and mean loss:

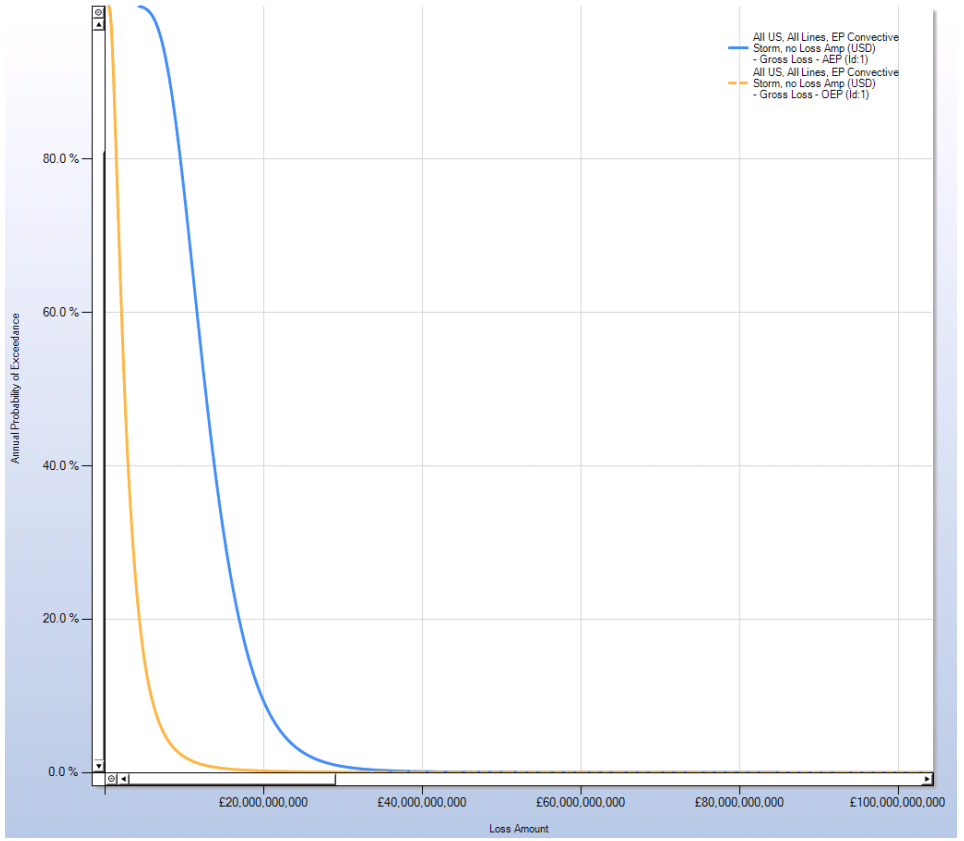
$$\sum_{i=1}^{N} L_i \times r_i$$

Alternatively:
The AAL is equivalent to the area under the AEP curve. This is an example of a **CAT statistic** because this approach is used for financial perspectives involving Cat treaties.

Interpreting an EP Curve

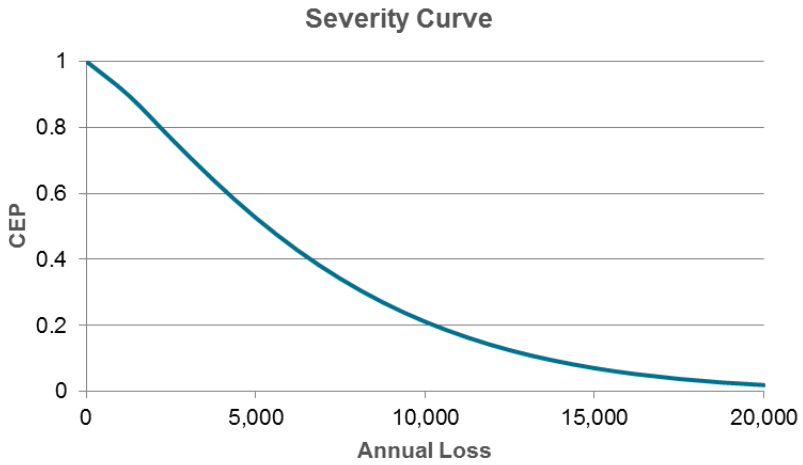
Event frequency impacts the distance between the OEP and AEP curves



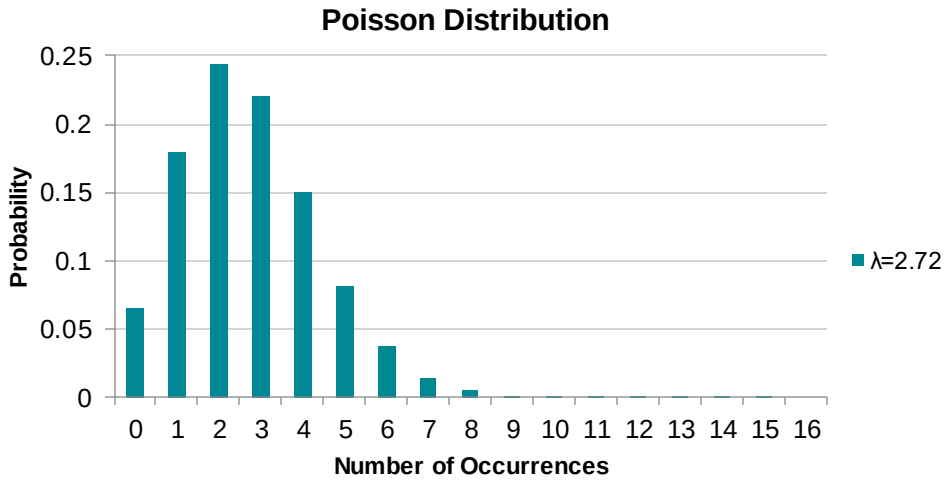


Exceedance Probability

SEVERITY DISTRIBUTION



FREQUENCY DISTRIBUTION



OEP

$$OEP(l) = 1 - e^{-\lambda.CEP(l)}$$

AEP

$$AEP(l) = \sum_{i=1}^{N} P(i) \times \boldsymbol{A^i} * \boldsymbol{S^i}$$

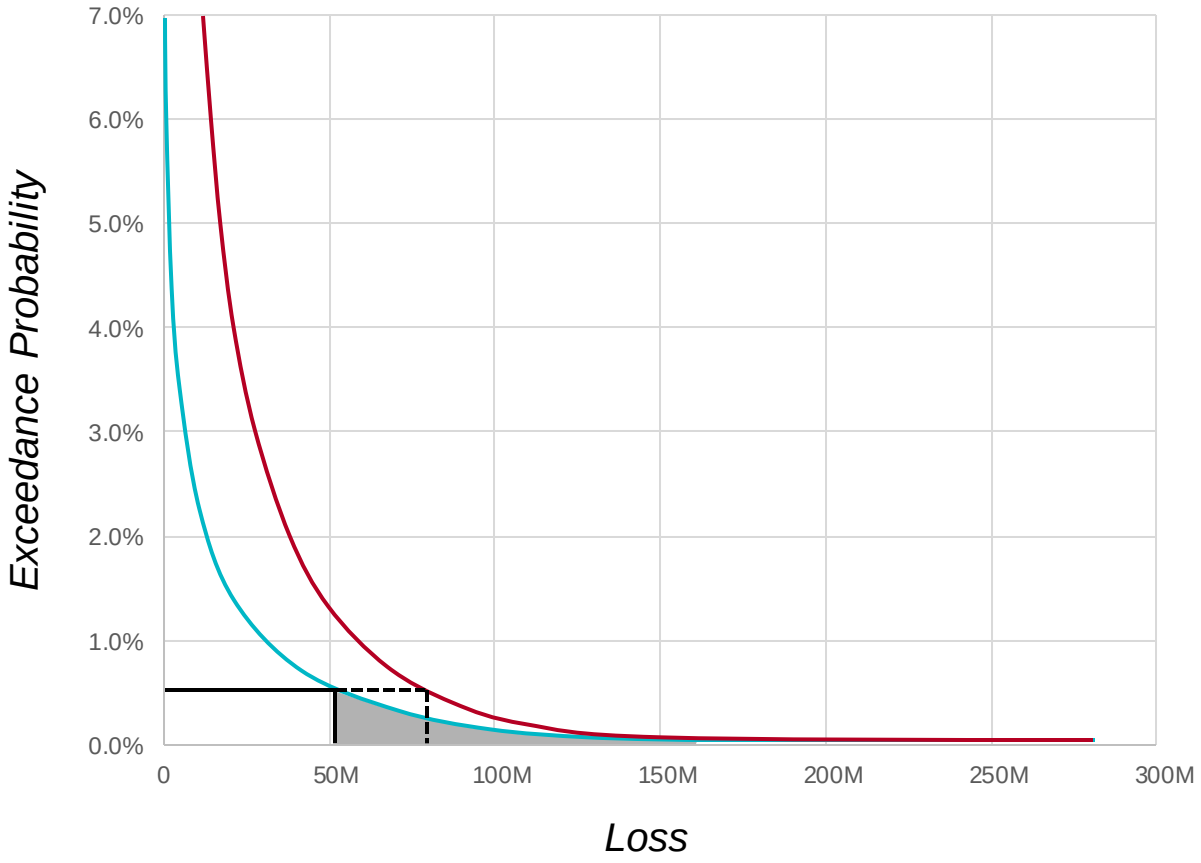
Tail Conditional Expectation

Tail Conditional Expectation (TCE) is the expected value of loss, given that a loss at least as large as X has occurred

- Answers the question: *Given that a loss that is at least as big as X has occurred, how big do we expect the loss to be?*
- TCE is measured for OEP and AEP

Tail Conditional Expectation (TCE)

How is it calculated? – An illustration



What is the TCE for $RPL_{0.5}$?

$RPL_{0.5}$ = 1 in 200 year Return Period Loss

$RPL_{0.5}$ = $51M

$TCE_{0.5} = RPL_{0.5}$ + (Shaded Area / 0.005)
= $51M + (0.14M / 0.005)
= $79M

TCE can be calculated for every financial perspective and every risk tolerance threshold with a loss exceedance probability greater than zero

EP Engines

RMS DLM Models use one of three different EP engines to generate EP curves based on the analysis type and financial perspective

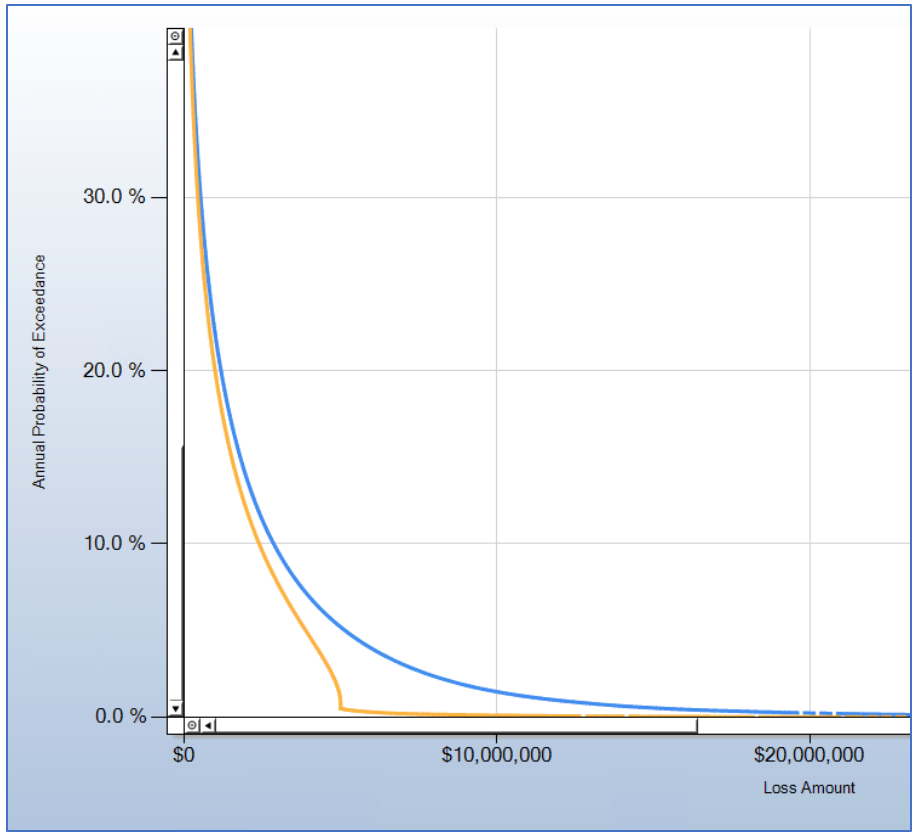
Regular EP engine: Uses the ELT of the financial perspective in question. Assumes a regular Beta distribution represents the loss distribution for each event.

Account/location EP engine: Uses the ELT of the underlying financial perspective. Truncations on these underlying distributions are computed using layer limits and attachments.

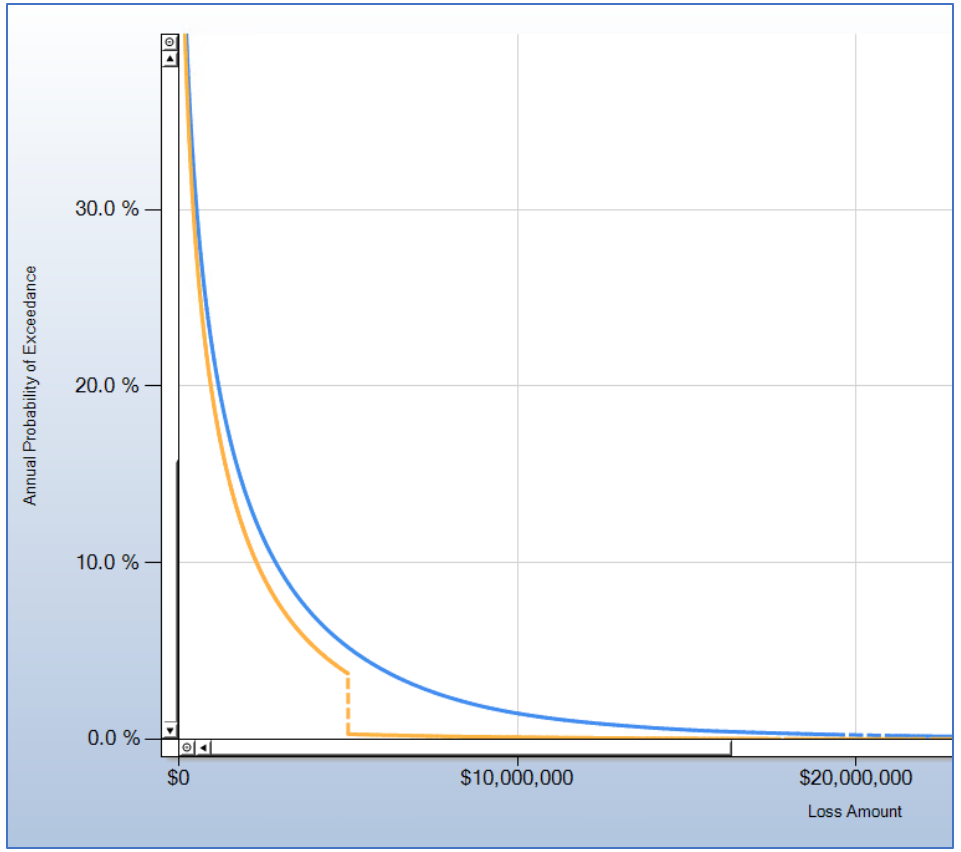
Cat EP Engine: Conceptually the same as account/location EP engine, but used in different analyses.

EP Engine Comparison

REGULAR EP CURVE



TRUNCATED EP CURVE



When are the Different EP Engines Used?

	Single portfolio analyses	Grouped portfolio analyses	Account/location analysis
Regular EP	GU Non-cat perspectives	All perspectives	GU
Account/Location EP	n/a	n/a	Non-cat perspectives
Cat EP	Cat perspectives	none	n/a

Grouping analyses

How does grouping ELTs work?

Analysis A

EventID	Rate	Mean Loss	StdDevC	StdDevI	Exposure
469292	0.0029	226,945	114,932	28,733	11,347,250
469282	0.0002	211,863	111,154	27,789	10,593,150
469293	0.0123	207,009	109,865	27,466	10,350,450
469266	0.0004	196,299	106,726	26,681	9,814,950
469283	0.0439	137,409	74,708	18,677	6,870,465

Analysis B

EventID	Rate	Mean Loss	StdDevC	StdDevI	Exposure
469292	0.003	181,556	91,946	22,986	9,077,800
573957	0.019	63,559	33,346	8,337	3,177,945
469293	0.012	238,060	126,345	31,586	11,903,018
469266	4E-04	78,520	42,690	10,672	3,925,980
584680	0.002	19,237	10,459	2,615	961,865

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Grouped A+B analysis

EventID	Rate	Mean Loss	StdDevC	StdDevI	Exposure
469292	0.003	408,501	206,878	36,796	20,425,050
469293	0.012	445,069	236,210	41,857	22,253,468
469266	4E-04	274,819	149,416	28,736	13,740,930

1. For events that are common to both analyses:

- Sums the mean losses, correlated standard deviation, and exposure value
- Calculates the square root of the sum of the squares for independent standard deviation

Grouping analyses

How does grouping ELTs work?

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2. Appends events that are not common to the group ELT without any modification

Grouping analyses

How does grouping ELTs work?

Analysis A

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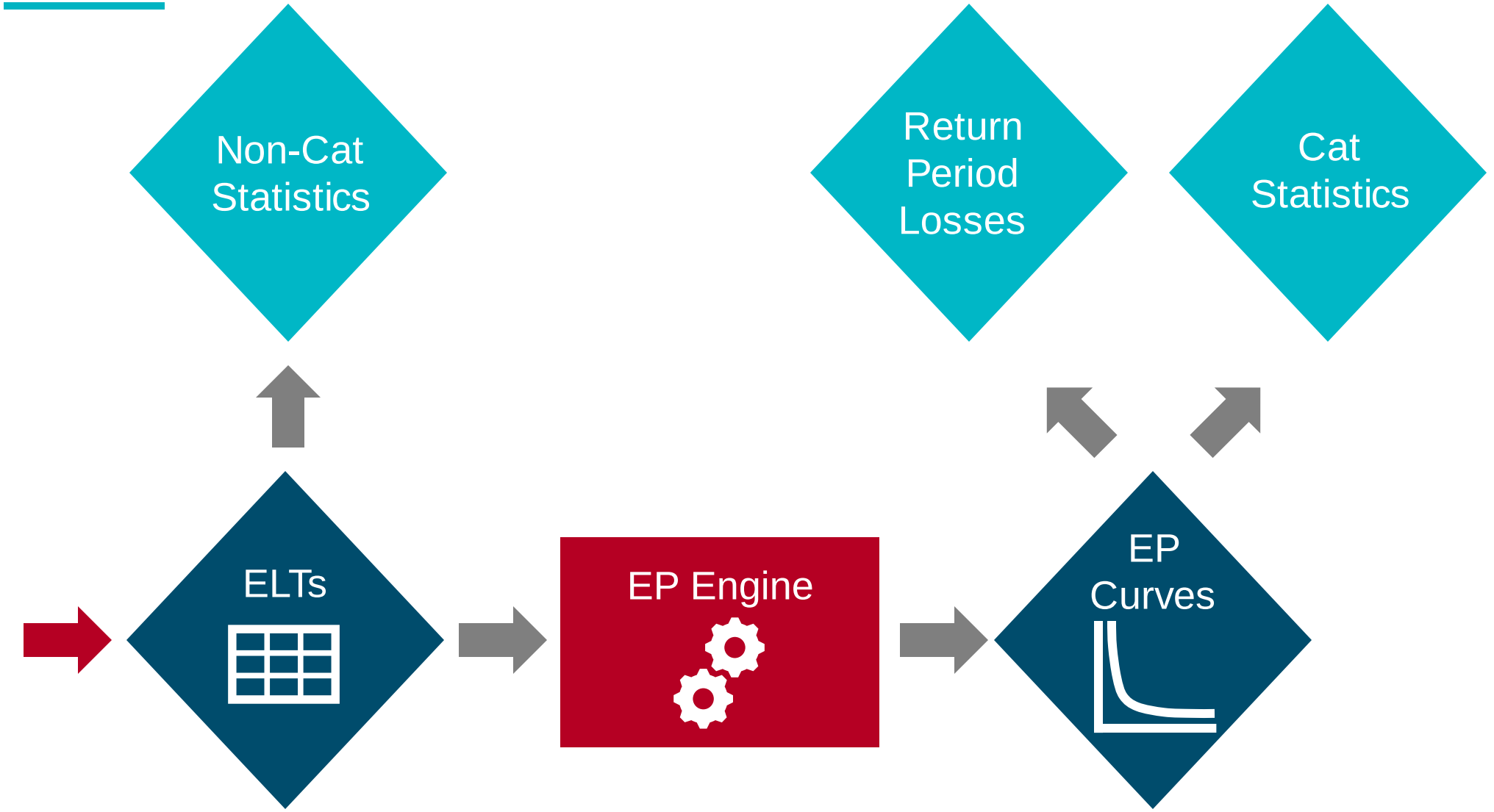
3. Statistics and EP curves are re-calculated from the grouped ELT

Financial Model Process Overview



FINANCIAL MODULE

INTERPRETING RESULTS

Key Applications

Underwriting

- Establish guidelines
- Differentiate risks
- Analyze policy structures
- Develop pricing

Portfolio Management

- Determine risk drivers
- Evaluate capital adequacy
- Allocate capital
- Estimate post-event losses

Risk Transfer

- Determine reinsurance needs
- Structure and price risk transfer
- Communicate with counterparties

Applications and Modeling Output

Underwriting

- Average Annual Loss
- Standard Deviation
- Return Period
- TCE
- CV

Portfolio

- Average Annual Loss
- Standard Deviation
- Return Period
- TCE
- CV
- XSAAL

Risk Transfer

- Average Annual Loss
- Standard Deviation
- Return Period
- TCE
- CV
- XSAAL

Applications and Modeling Output

Underwriting

- Average Annual Loss
- Standard Deviation
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Portfolio

- Average Annual Loss
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- CV
- XSAAL

Risk Transfer

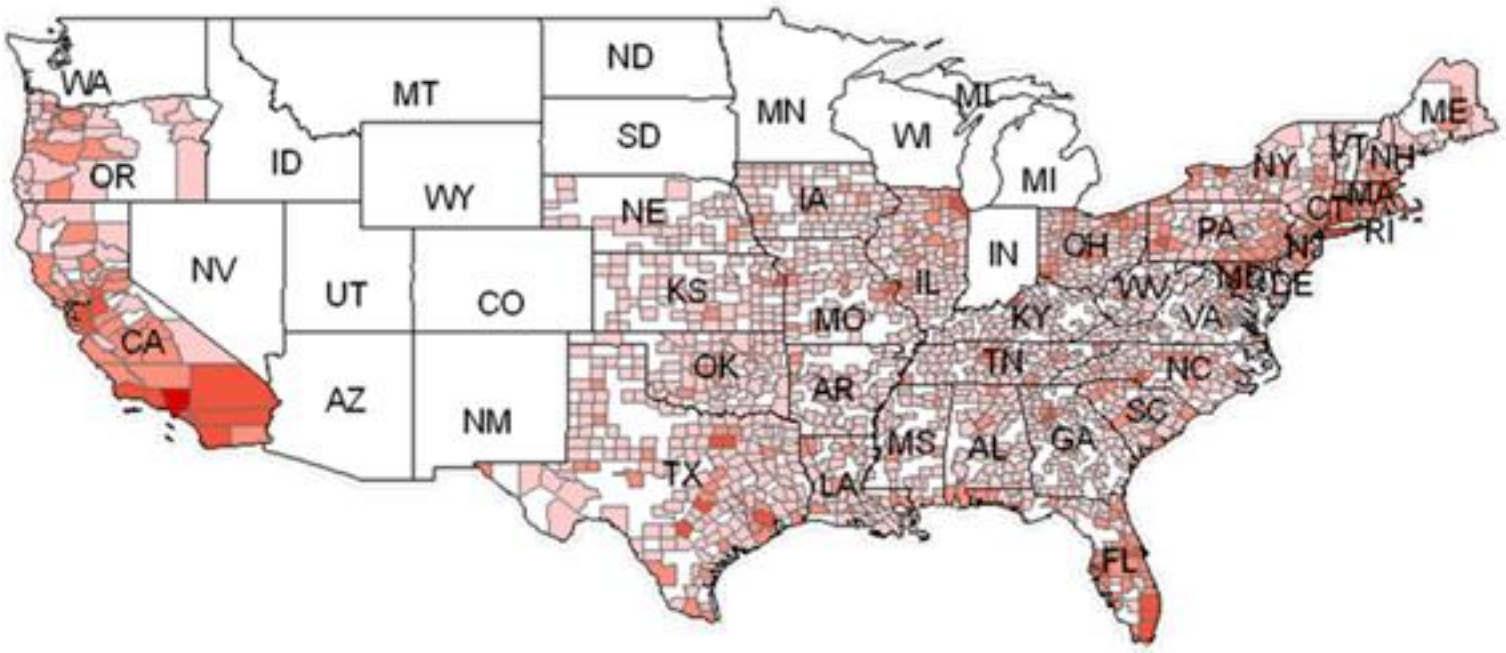
- Average Annual Loss
- Standard Deviation
- Return Period
- TCE
- CV
- XSAAL

INTERPRETING RESULTS

CURRENT BOOK OF BUSINESS

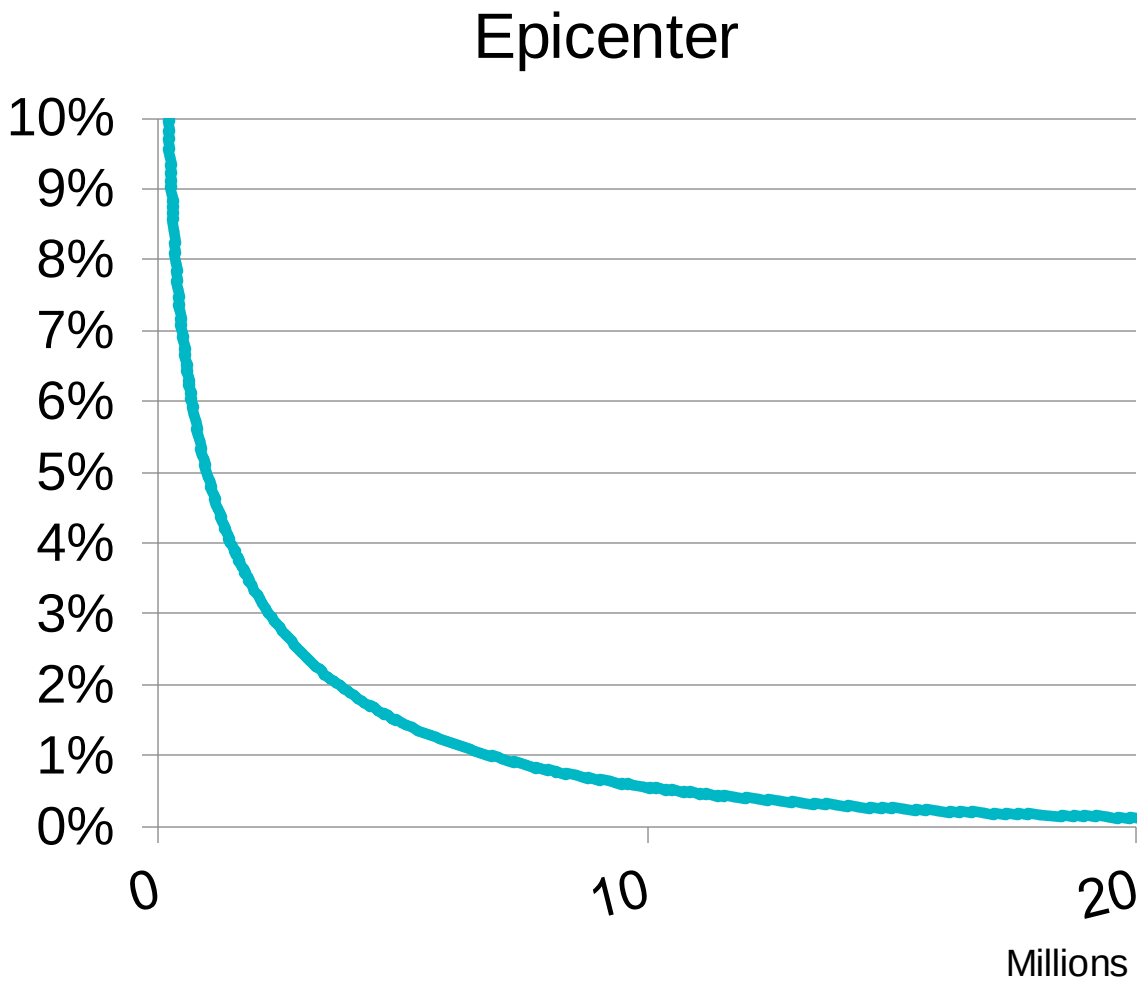
Epicenter Insurance

- Our Scenario
  - Insurance Company looking at two new accounts
  - Natural Catastrophe Perspective
- National Book of Business
- Concentrations in California, Illinois and Tennessee



Epicenter Portfolio

Return Period	Epicenter Ins Gross OEP ($M)
5,000	35.8
1,000	22.3
500	16.8
250	12.1
100	6.8
50	3.7
AAL	278K
Std Dev	1,670K

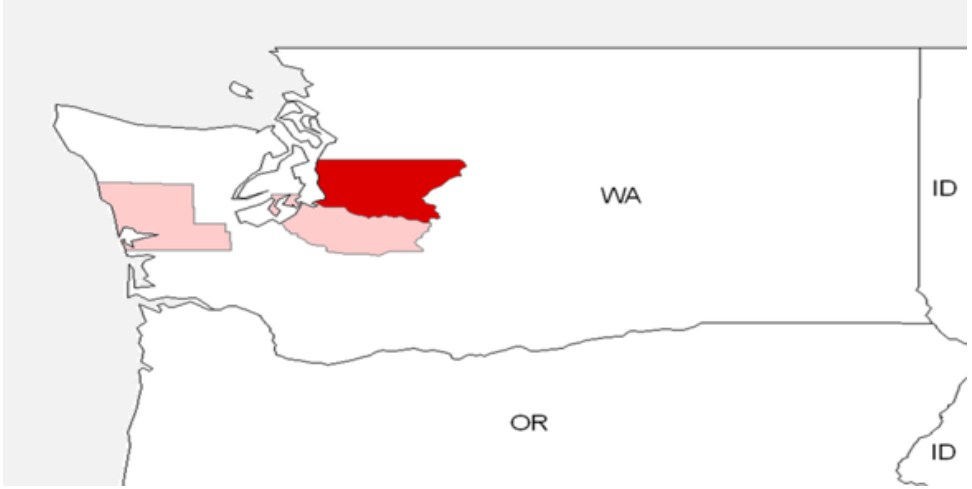


INTERPRETING RESULTS

POTENTIAL NEW BUSINESS

Pacific Puzzle

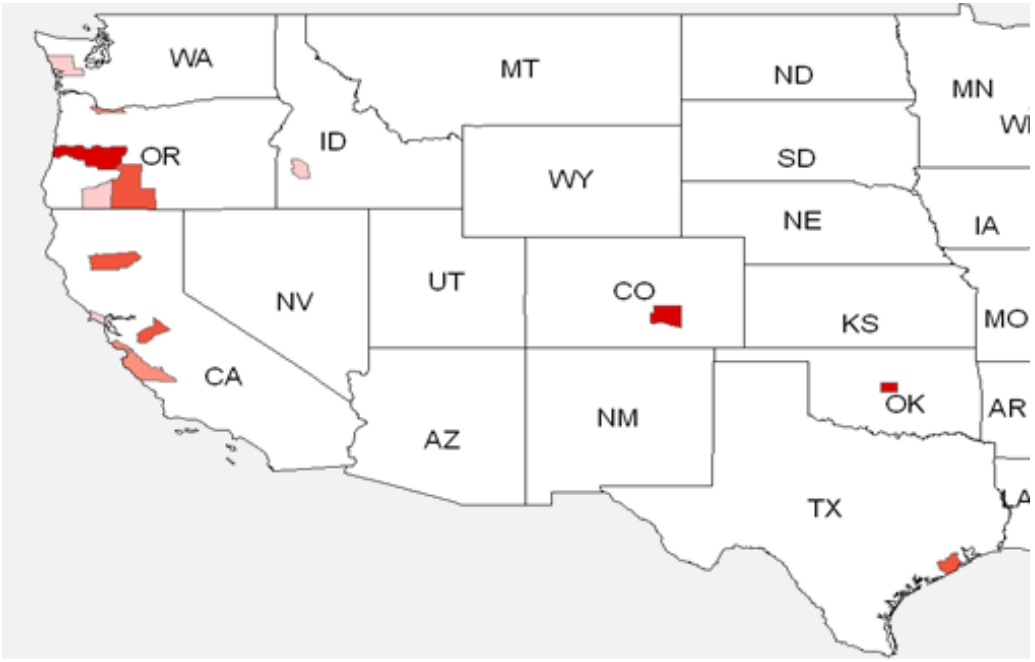
- State of Washington
- Manufactures puzzles
- Retails puzzles and games



Number of Locations	42
Total Insured Value	$44.7M
Deductible	5% Blanket (Policy)
Policy Structure	Full Limit

Sunny Sandals

- CA, CO, OK, OR, TX
- Manufactures sandals
- Retails sandals and accessories



Number of Locations	100
Total Insured Value	77.9M
Deductible	5% Blanket (Policy)
Policy Structure	10M x 1M

INTERPRETING RESULTS

WHICH SHOULD WE WRITE?

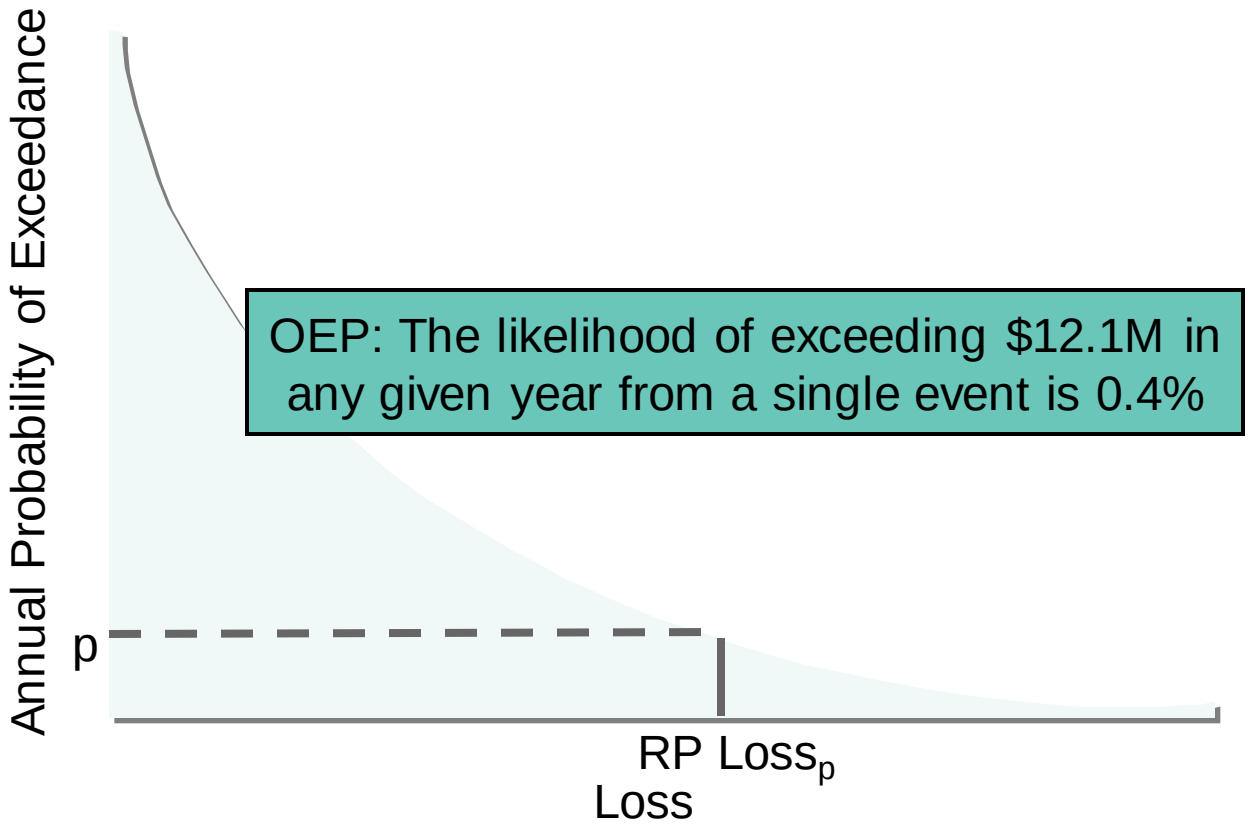
Exceedance Probability Curves

- Occurrence Exceedance Probability (OEP)
  - Probability that the single largest event loss in a year will exceed a loss threshold.
- Aggregate Exceedance Probability (AEP)
  - Probability that the aggregate event losses in a year will exceed a threshold.
  - Considers the possibility of having multiple occurrences in one year.

Return Period Loss

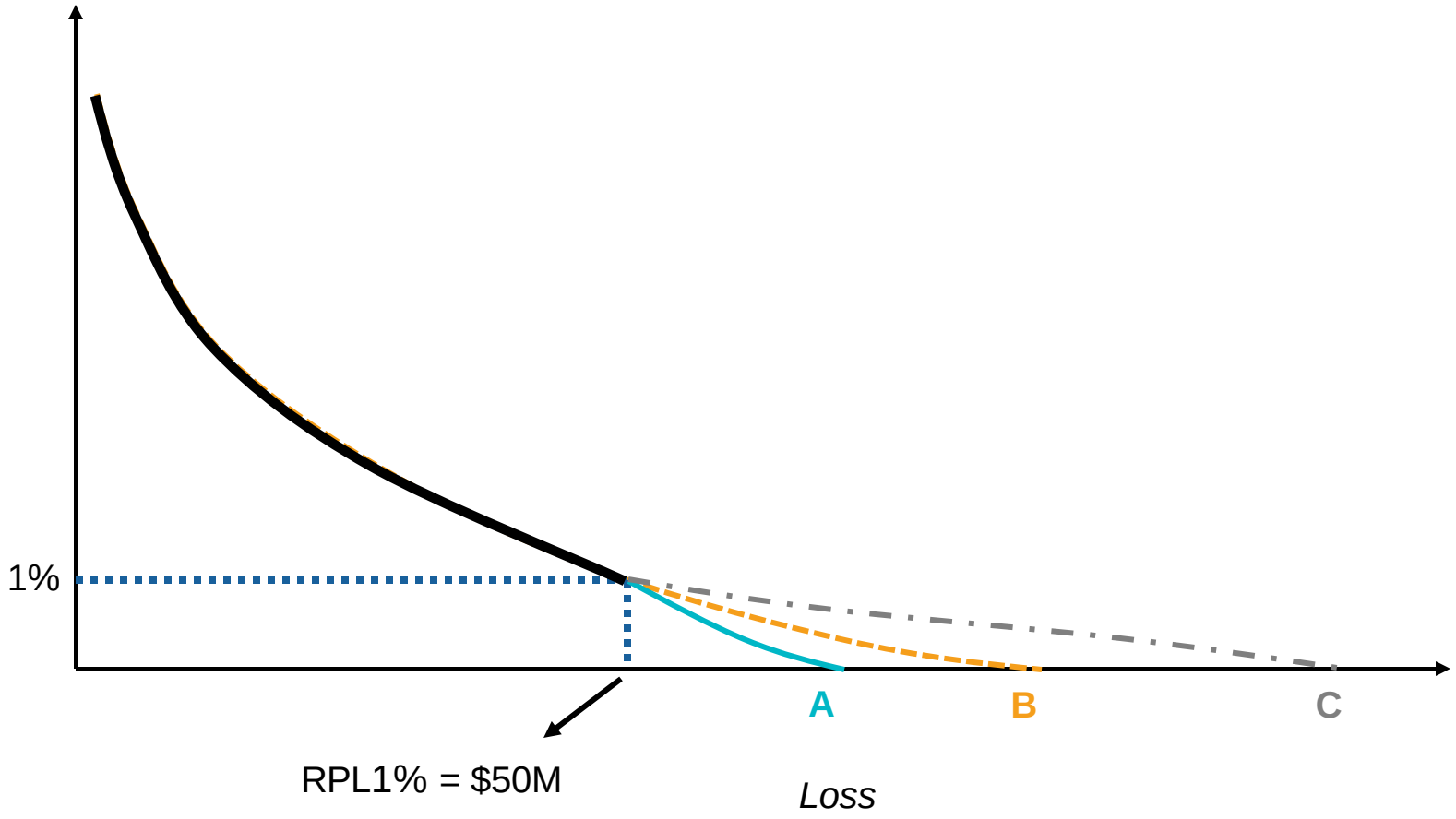
- Loss corresponding to a point on a loss curve that describes the likelihood of exceeding a loss threshold from:
  - … the single largest event (OEP), or
  - … the aggregation of one or more events (AEP)

Return Period	Epicenter Ins Gross OEP ($M)
250	12.1



Return Period Loss

A single return period loss does not differentiate risks with different tail distributions.

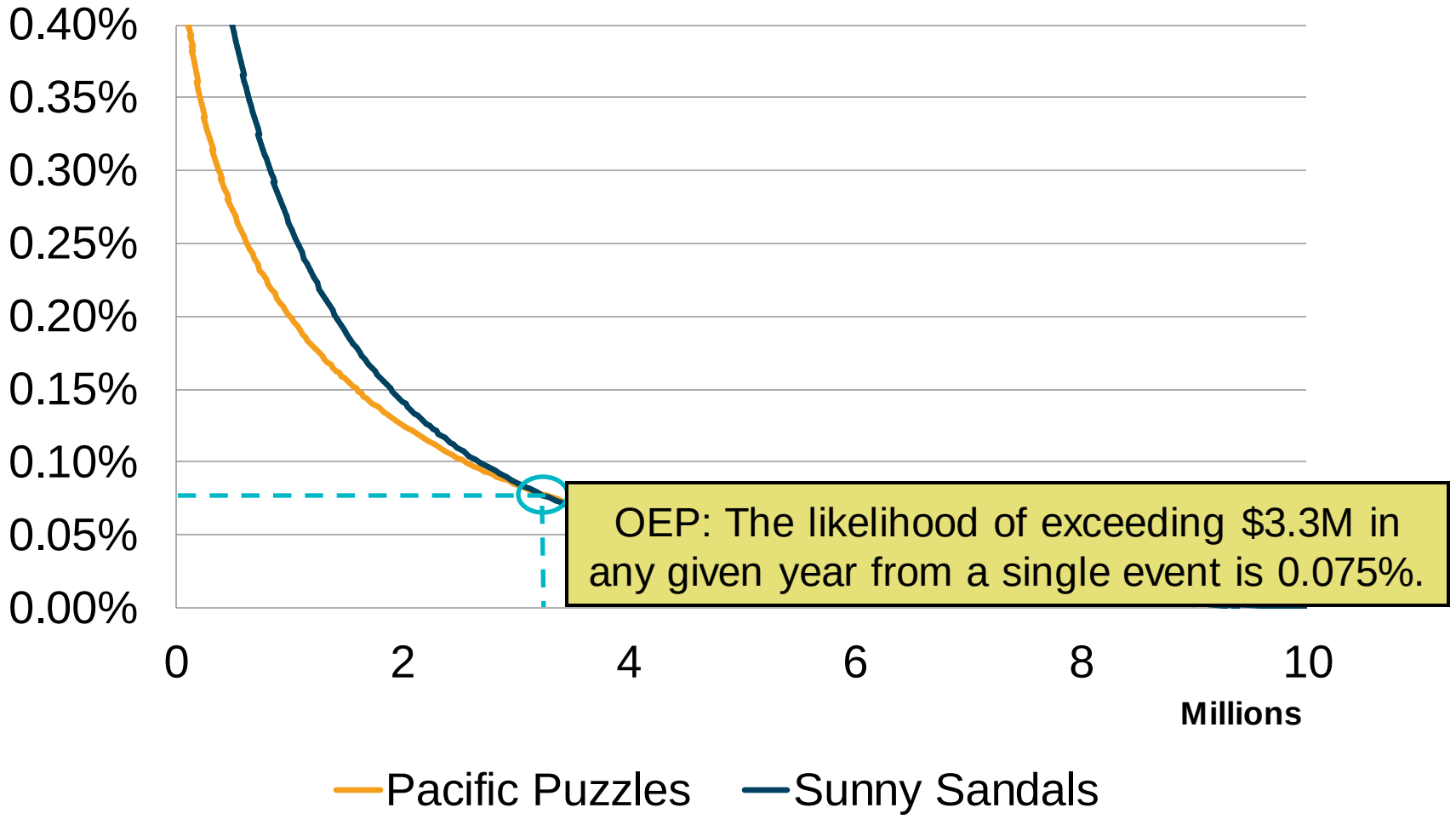


Account Gross Loss Comparison

Return Period	Pacific Puzzles OEP ($M)	Sunny Sandals OEP ($M)
5,000	7.8	6.3
1,000	2.6	2.7
500	1.0	1.4
250	0.1	0.5
100	0.0	0.3

Which account would you choose to add?

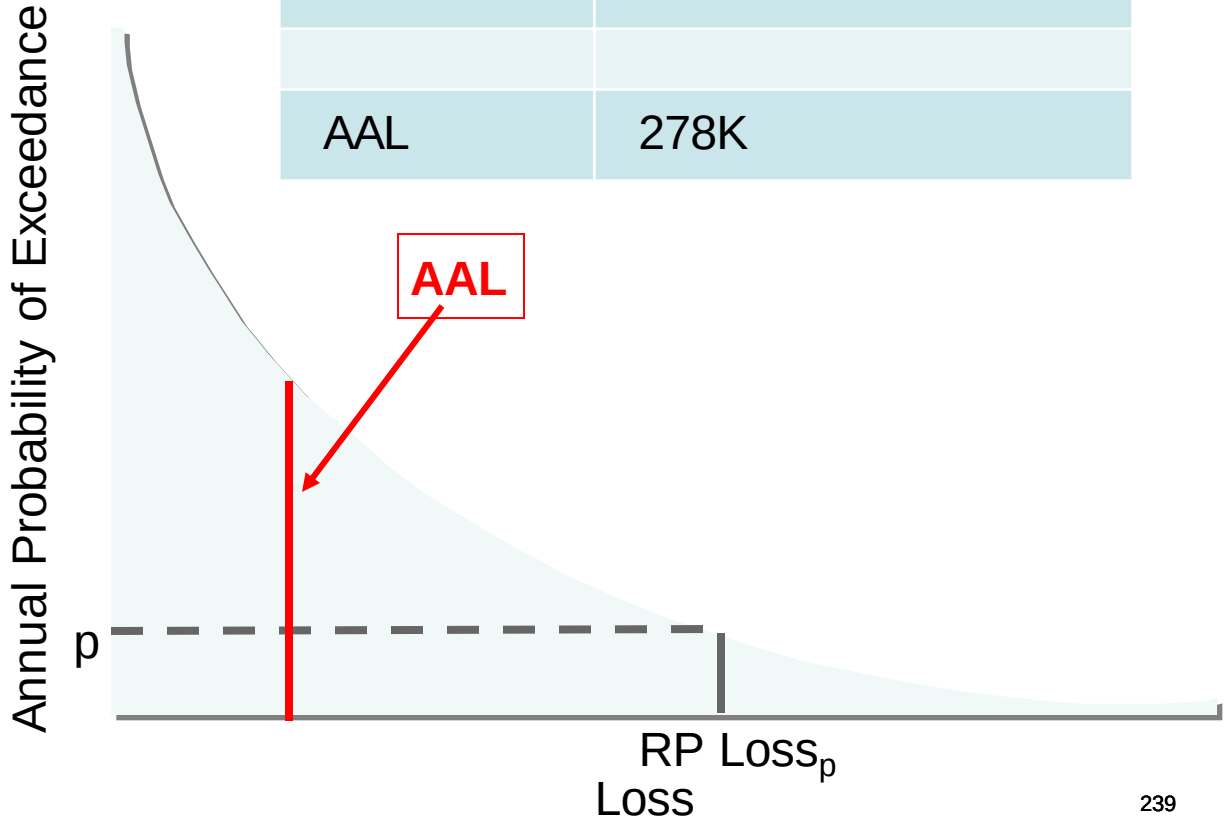
Account Comparison – OEP Curve



Average Annual Loss

- The expected value of the aggregate loss distribution
- Premium needed to cover loss from a peril over time
- Losses from any given year will be higher/lower than AAL
- Also called “Pure Premium”

Return Period	Epicenter Ins Gross OEP
250	12.1M
AAL	278K



Account AAL Comparison

- Which risk is better?
- Is there enough information?
- Considerations:
  - Market Price
  - Risk Tolerance
  - Loss Variability

	Pacific Puzzles ($)	Sunny Sandals ($)
AAL	8,400	9,400

Uncertainty

Even “perfect” information cannot lead to perfect prediction or estimation of losses from infrequent perils.

Uncertainty measures variability from mean, or expected value.

How much will losses vary from the mean loss, or Average Annual Loss, in a given, specific year?

Volatility

- Mean losses will fluctuate from year to year
  - Peaks and valleys
- Volatility measures the amount of fluctuation
- Measurement
  - CV = Standard Deviation ÷ Average Annual Loss
    - Normalized (unitless)
    - Used for comparisons
- Frequency of events is primary driver

How much will the mean loss, or Average Annual Loss, vary from year to year?

Standard Deviation and Volatility

Year	1	2	3	4	5	6	7	8	9	10
A	0	0	10	0	0	0	0	0	0	0
B	1	1	1	1	1	1	1	1	1	1

Example	AAL	Std Dev
A	1.0	3.0
B	1.0	0.0

Standard Deviation and Volatility

Year	1	2	3	4	5	6	7	8	9	10
A	10	0	40	15	0	10	20	0	10	25
B	0	60	0	30	0	25	45	50	0	75

Example	AAL	Std Dev
A	13	12.1
B	29	26.7

Account Uncertainty / Volatility

Standard Deviation (Uncertainty)

- Measurement of spread of loss around mean loss

CV (Volatility)

- Unitless, Comparative

Gross Loss	Pacific Puzzles ($)	Sunny Sandals ($)
Pure Premium	8,400	9,400
Standard Deviation	226,900	179,400
Coefficient of Variation	27.0	19.1

$$CV = \frac{StDev}{AAL}$$

Pricing the Accounts

This is a simplified pricing formula.

Other possible considerations in pricing include:

- Profit Expectation
- Investment Income
- Company Claim History
- Filing Jurisdiction Requirements
- Allocated and Unallocated Expenses
- Others

- Pure Premium = Average Annual Loss
- Loaded Pure Premium = Pure Premium + X% SD

Our Loaded Pure Premium = AAL + 20% SD

Pricing the Accounts

- Pure Premium = Average Annual Loss
- Loaded Pure Premium = Pure Premium + X% SD

Our Loaded Pure Premium = AAL + 20% SD

Gross Loss	Pacific Puzzles ($)	Sunny Sandals ($)	% Diff
Pure Premium	8,400	9,400	+12%
Standard Deviation	226,900	179,400	N/A
Coefficient of Variation	27.0	19.1	-29%
Loaded Pure Premium	$53,780	$45,280	-16%

Pricing the Accounts

Probability of exceeding loaded pure premium from a single event in a given year?

Return Period	Pacific Puzzles ($K)	Sunny Sandals ($K)
5,000	7,781	6,347
1,000	2,567	2,686
500	1,005	1,411
250	112	500
223	53	390
121	0	45
100	0	0

0.45%

0.83%

Portfolio and Account Gross Losses Grouped

Grouped Losses Return Period

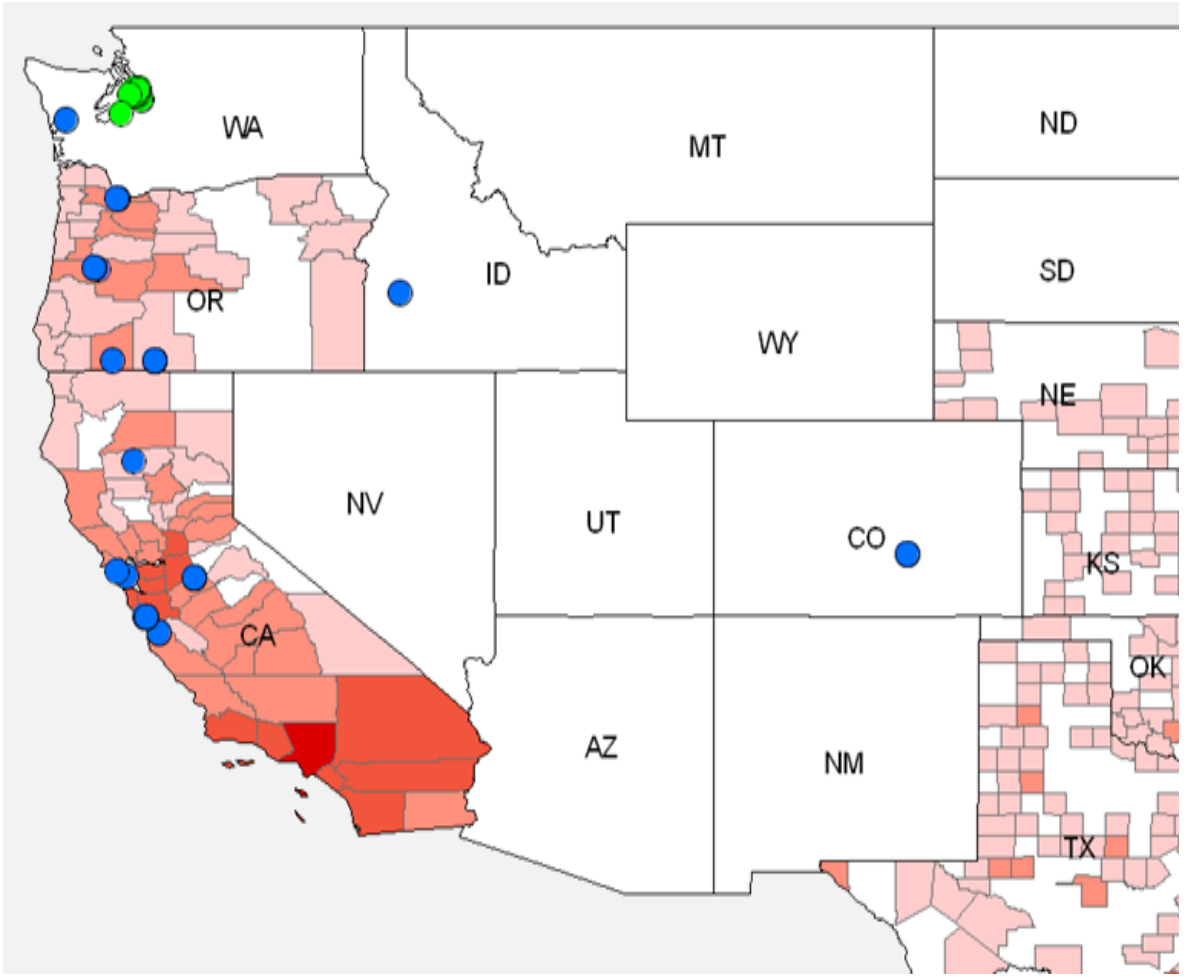
Return Period	Epicenter ($M)	Epicenter + Pacific Puzzles ($M)	Epicenter + Sunny Sandals ($M)
5,000	35.8	35.9	38.3
1,000	22.3	22.4	23.1
500	16.8	17.0	17.3
250	12.1	12.2	12.4
100	6.8	6.9	6.9
50	3.7	3.8	3.8

Grouped Losses AAL and CV

- Grouped gross AAL similar
- One account diversifies book, one does not.
  Why?

Statistic	Epicenter ($K)	Epicenter and Pacific Puzzles ($K)	Epicenter and Sunny Sandals ($K)
AAL	278	287	288
Std Dev	1,639	1,660	1,698
CV	5.89	5.78	5.90

Diversification



Return Period Losses

Account Comparison Summary

- Check #1: Return Period Losses
  - Pacific Puzzles higher at long return periods (no clear choice)

Return Period	Pacific Puzzles OEP ($K)	Sunny Sandals OEP ($K)
5,000	7.8	6.3
1,000	2.6	2.7
500	1.0	1.4
250	0.1	0.5
100	0.0	0.3

Recall: curves cross here

Pure Premium

Account Comparison Summary

- Check #1: Return Period Losses
  - Pacific Puzzles higher at long return periods (no clear choice)
- Check #2: Pure Premium
  - Pacific Puzzles < Sunny Sandals

	Pacific Puzzles ($)	Sunny Sandals ($)
Pure Premium	8,400	9,400
Standard Dev	226,900	179,400
CV	27.0	19.1
Loaded PP	53,780	45,280

Uncertainty and Volatility

Account Comparison Summary

- Check #1: Return Period Losses
  - Pacific Puzzles higher at long return periods (no clear choice)
- Check #2: Pure Premium
  - Pacific Puzzles < Sunny Sandals
- Check #3: Uncertainty and Volatility
  - Pacific Puzzles > Sunny Sandals
  - Impact on profitability

	Pacific Puzzles ($)	Sunny Sandals ($)
Pure Premium	8,400	9,400
Standard Dev	226,900	179,400
CV	27.0	19.1
Loaded PP	53,780	45,280

Diversification

Account Comparison Summary

- Check #1: Return Period Losses
  - Pacific Puzzles higher at long return periods (no clear choice)
- Check #2: Pure Premium
  - Pacific Puzzles < Sunny Sandals
- Check #3: Uncertainty and Volatility
  - Pacific Puzzles > Sunny Sandals
  - Impact on profitability
- Check #4: Diversification
  - Look at combined EPs

Return Period	Epicenter OEP ($M)	Epicenter + Pacific Puzzles OEP ($M)	Epicenter + Sunny Sandals OEP($M)
5,000	35.8	35.9	38.3
1,000	22.3	22.4	23.1
500	16.8	17.0	17.3
250	12.1	12.2	12.4
100	6.8	6.9	6.9

Diversification

Account Comparison Summary

- Check #1: Return Period Losses
  - Pacific Puzzles higher at long return periods (no clear choice)
- Check #2: Pure Premium
  - Pacific Puzzles < Sunny Sandals
- Check #3: Uncertainty and Volatility
  - Pacific Puzzles > Sunny Sandals
  - Impact on profitability
- Check #4: Diversification
  - Look at combined Eps
  - And combined CVs
  - Pacific puzzles creates diversification

Statistic	Epicenter ($K)	Epicenter + Pacific Puzzles ($K)	Epicenter + Sunny Sandals ($K)
AAL	278	287	288
Std Dev	1,639	1,660	1,698
CV	5.89	5.78	5.90

Final Choice

Which account should we write?

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Our New Account

- Return Period Losses smaller at lower return periods
- Loaded Pure Premium: $53,813
  - Market can bear premium
  - Assumes similar profit by account
- More account volatility
- When grouped with portfolio – change in CV indicates diversification
- Map visualization verifies diversification

Pacific Puzzles

QUESTIONS ?