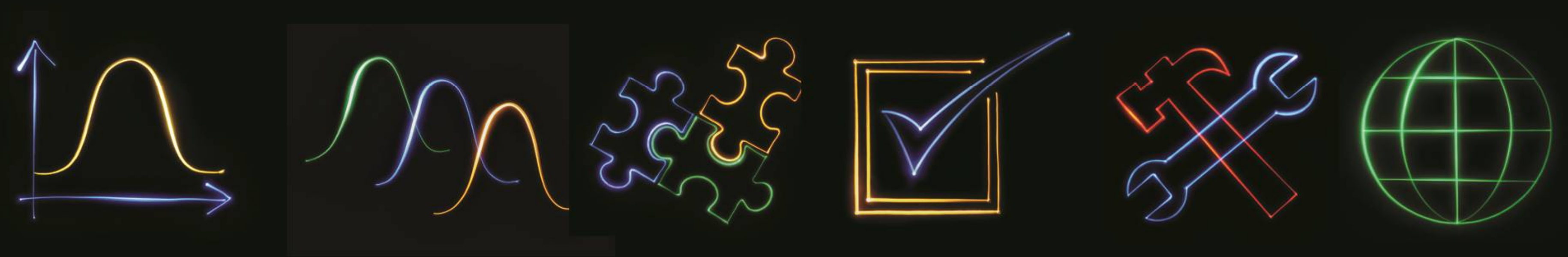
MANAGING EXTREMES Willis Re

REINSURANCE BOOT CAMP ON PRICING TECHNIQUES

Catastrophe Modeling

August 12, 2013



Reinsurance Boot Camp on Pricing Techniques

Catastrophe Modeling

August 12, 2013

Ephraim Ames
SVP Willis Re

Agenda

- Today's topics
  - **Modeling methodologies**
  - Understanding and applying model output
  - Data management and procedures

Modeling methodology

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- Brief history of catastrophe modeling
- Catastrophe models are used to quantify large loss potential, loss frequency, and manage exposures
  - Actuarial techniques are inappropriate due to lack of significant historical data
- Basic model methodology
  - Using hurricane and earthquake as examples
- Modeling output used in (re)insurance:
  - Expected (modeled) annual losses used in policy rating / pricing
  - Estimated large loss potential – used in reinsurance program design / decision making
  - Probabilistic modeling & Deterministic modeling

Exposure management - prior to Hurricane Andrew

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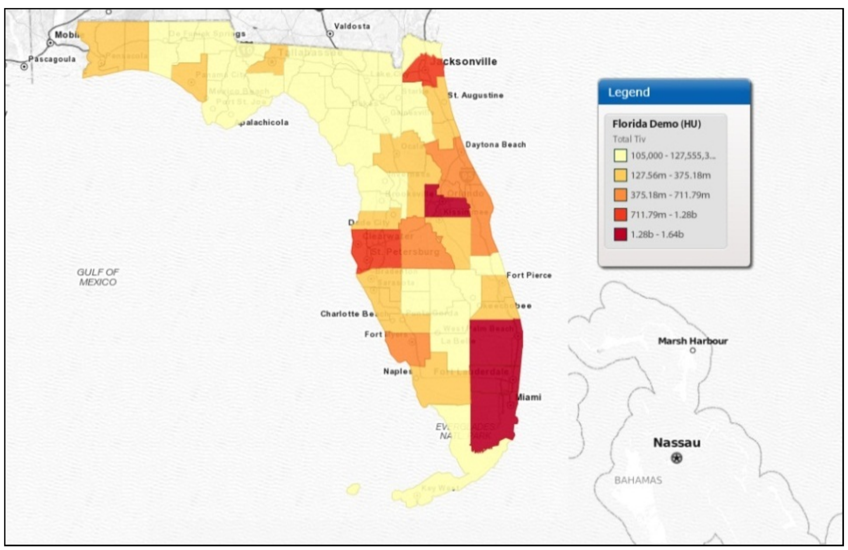
- Focus was solely on aggregates by geographic region
  - Most if not all reporting was done via spreadsheet reports and mapping capabilities were minimal at best
  - Commercial catastrophe models were in their infancy and not widely used



Property Exposure by State / County Example of Portfolio Management Example Insurance Company Data as of 12/31/1992			
State	**County**	**Total Insured Value**	**% to Total**
FL	ORANGE	$1,663,665,405	10.1%
FL	BROWARD	$1,566,156,920	9.5%
FL	MIAMI-DADE	$1,484,899,000	9.0%
FL	PALM BEACH	$1,458,720,300	8.9%
FL	HILLSBOROUGH	$1,097,528,970	6.7%
FL	PINELLAS	$900,557,300	5.5%
FL	DUVAL	$780,494,810	4.7%
FL	LEE	$640,083,150	3.9%
FL	SEMINOLE	$586,036,600	3.6%
FL	VOLUSIA	$542,829,800	3.3%
FL	BREVARD	$473,481,955	2.9%
FL	POLK	$410,221,500	2.5%
FL	SARASOTA	$342,229,900	2.1%
FL	OSCEOLA	$339,823,000	2.1%
FL	PASCO	$315,492,500	1.9%

Development of catastrophe models

- Insurance companies need the ability to quantify not only large loss potential, but also loss frequency
  - Probabilistic and Deterministic (Scenario) modeling
- Historical loss information alone may not be credible for long range projections
- Today, catastrophe models are used for proactive management of catastrophe-exposed property exposures
  - Commercial models, proprietary models, and geospatial tools
- Exposure management will become more of a key going forward though

Modeling and exposure management in today's environment

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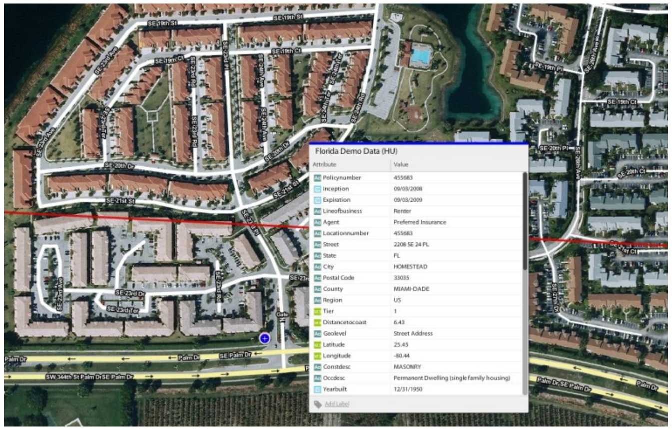
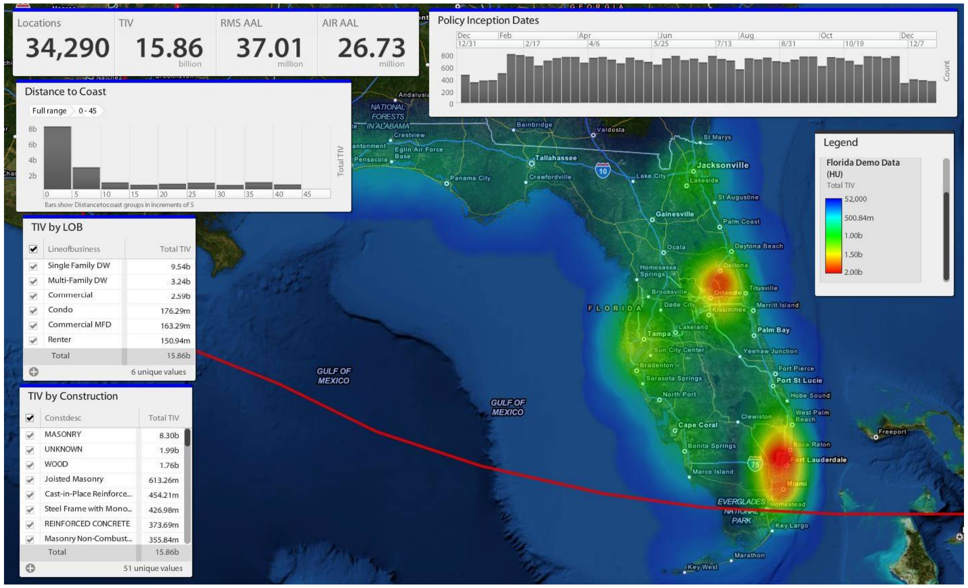
- Sophisticated stochastic modeling and spatial analysis
- Commercial catastrophe models are the benchmark in the industry along with location intelligence
- Sophisticated underwriting techniques are essential to managing for profitability





Catastrophe models

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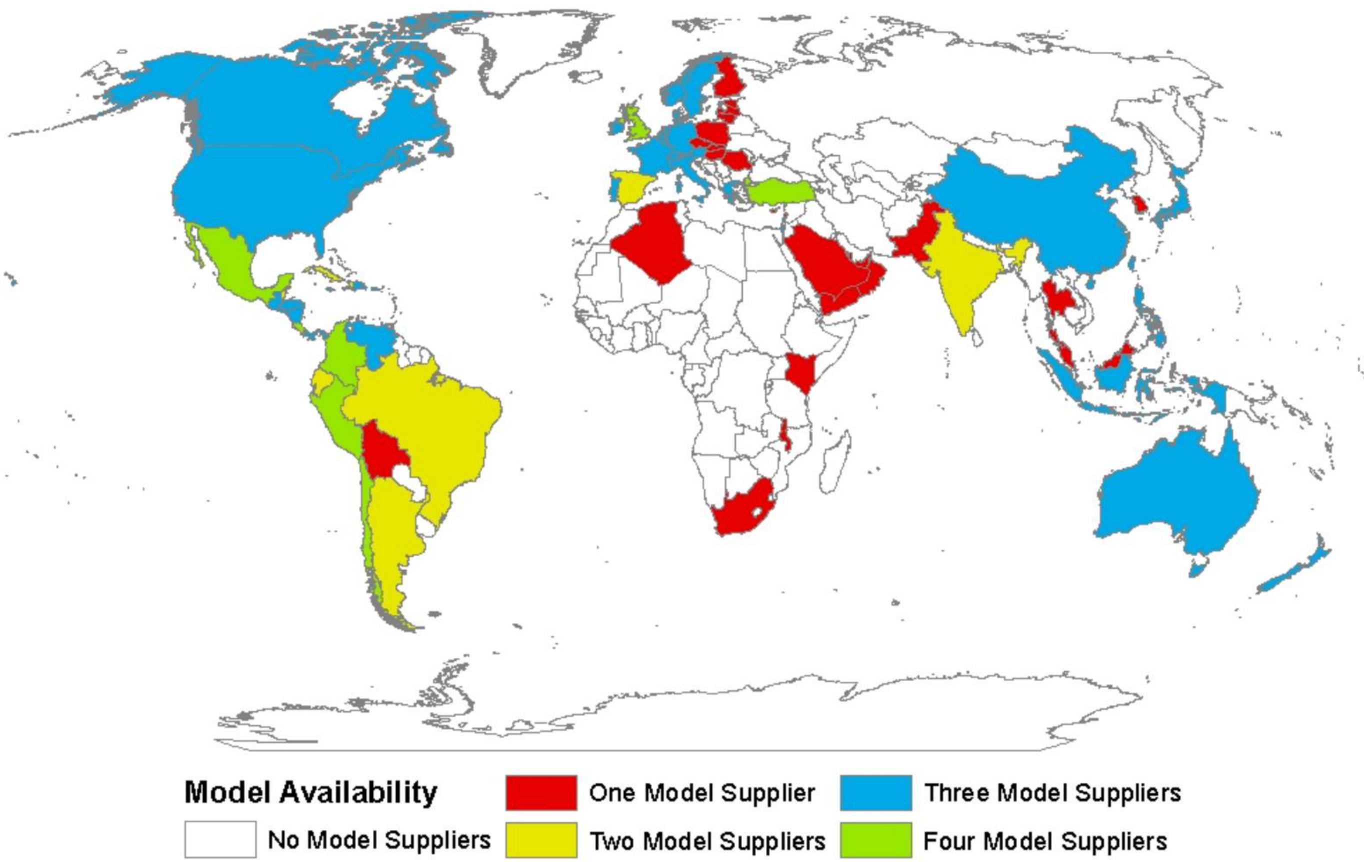
- AIR, RMS, EQECAT
  - Vendor chosen varies by geography
    - U.S., Europe, Japan, etc.
  - Commonly weight two or more models
    - Weighting varies by peril and geography
- Detailed vs. aggregate (market share) models
  - Usage varies by market domicile
    - Bermuda, London, U.S.

AIR WORLDWIDE RMS™ EQECAT An ABS Consulting Company

Commercial cat model availability

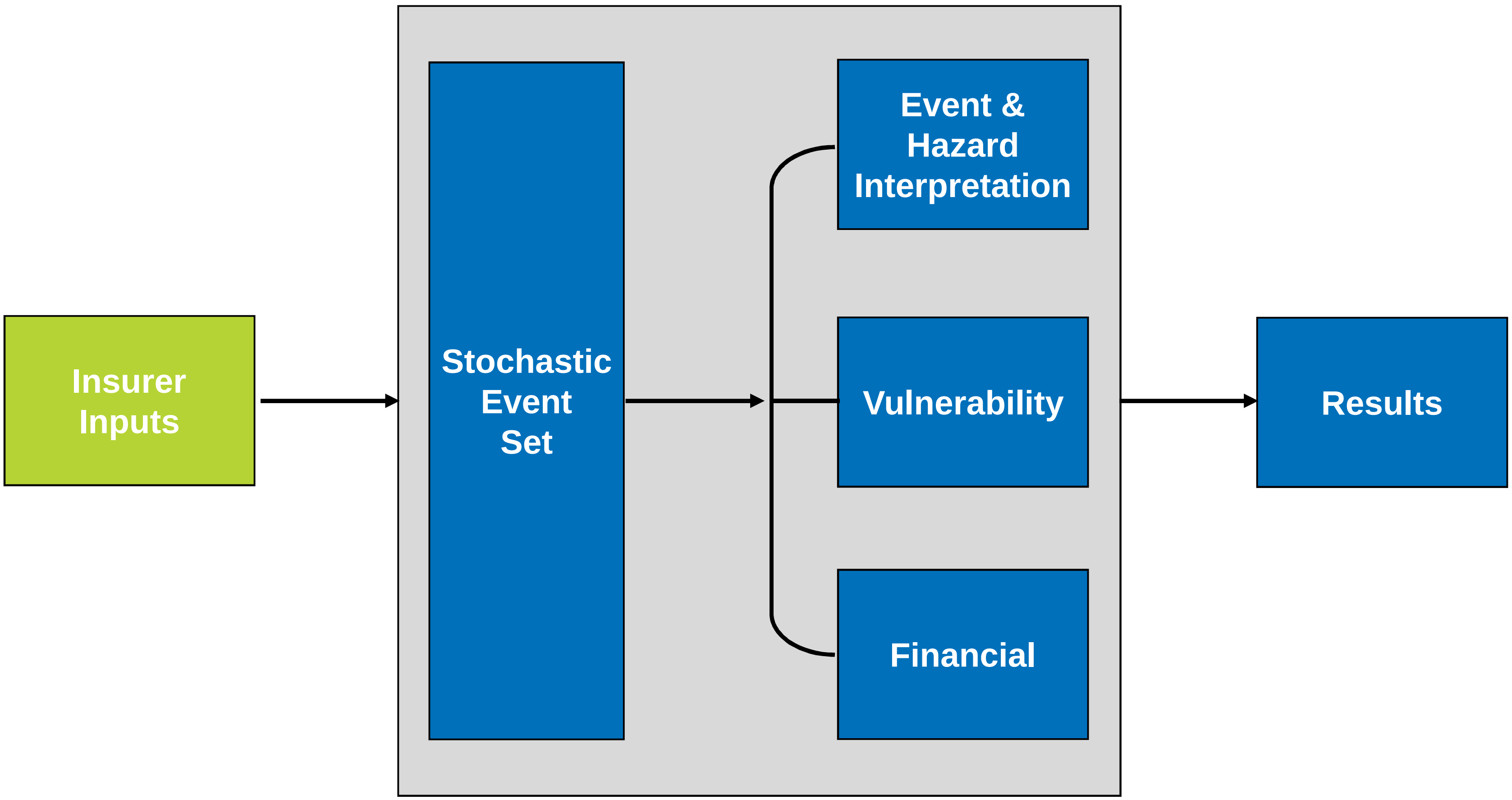


- 90% of the world's GDP
- 400+ country-peril combinations

Available perils in commercial models

- Models offer coverage for over 50 countries / territories
- Perils covered for Property include:
  - Earthquake
  - Fire following earthquake
  - Tropical cyclone (hurricanes, typhoons, and cyclones)
  - Extra-tropical cyclone (windstorm)
  - Storm Surge
  - River flooding
  - Severe Convective Storm
  - Terrorism
  - Winter Storm
  - Wildfire

Basic model methodology

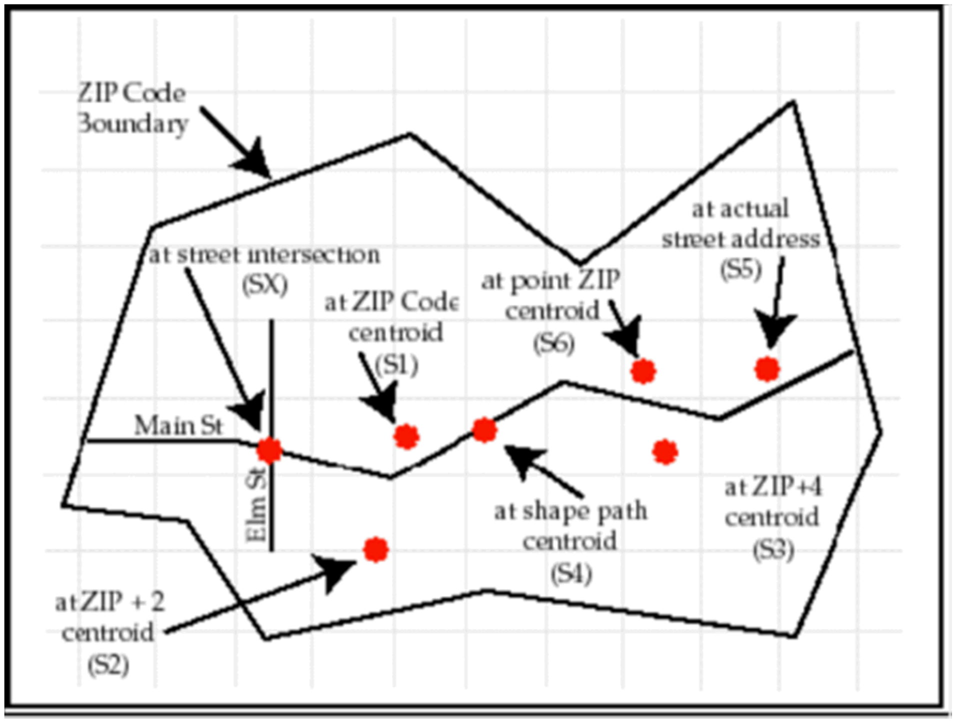


Insurer inputs – general

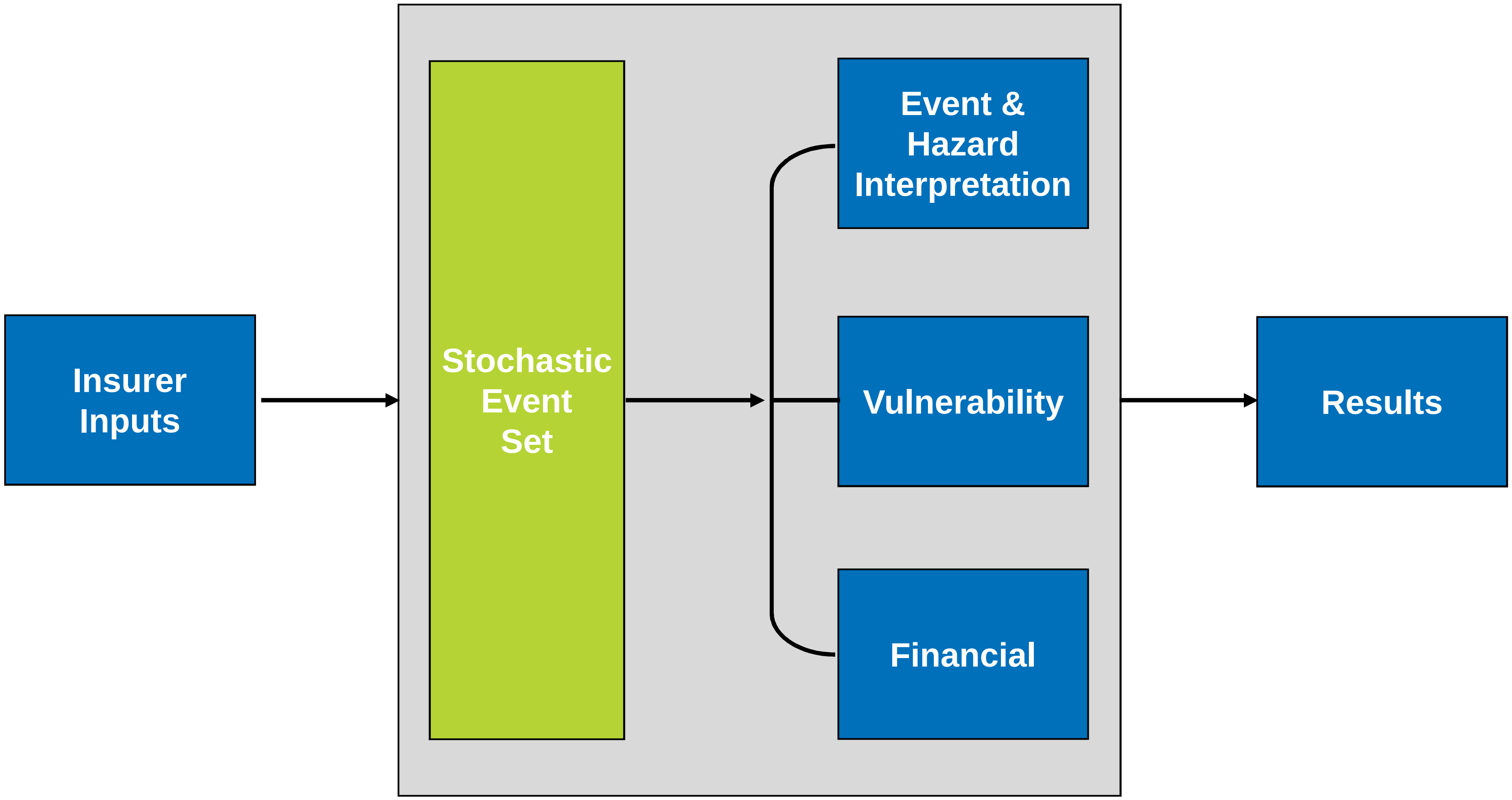
- Location
  - Street address
  - Zip code
  - County
  - State
- Risk characteristics
  - Construction type
  - Occupancy type
  - Year of construction
  - Number of stories
  - Secondary modifiers
- Values
  - Coverage values
  - Premiums
  - Payroll (WC)
  - Number of employees (WC)
- Financial terms / reinsurance
  - Limits (coverage, policy, etc.)
  - Deductibles
  - Reinsurance (FAC, XPR, XOL, SS, QS)
  - Co-insurance

Insurer inputs – geocoding

- Assign a latitude / longitude coordinate
- The specific coordinates define the hazard parameters
- More accurate geocoding correlates to more accurate results
  - Coordinate
  - Street
  - Postal Code
  - City
  - County
  - CRESTA

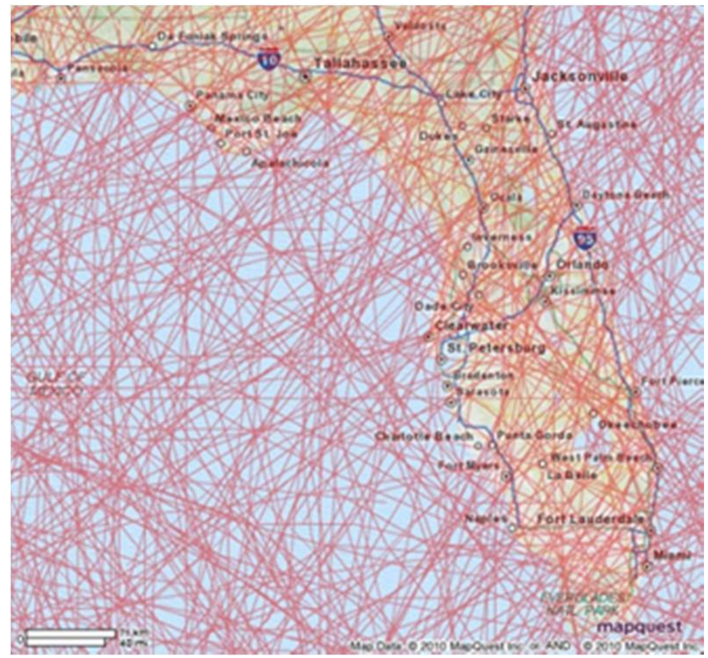


Basic model methodology



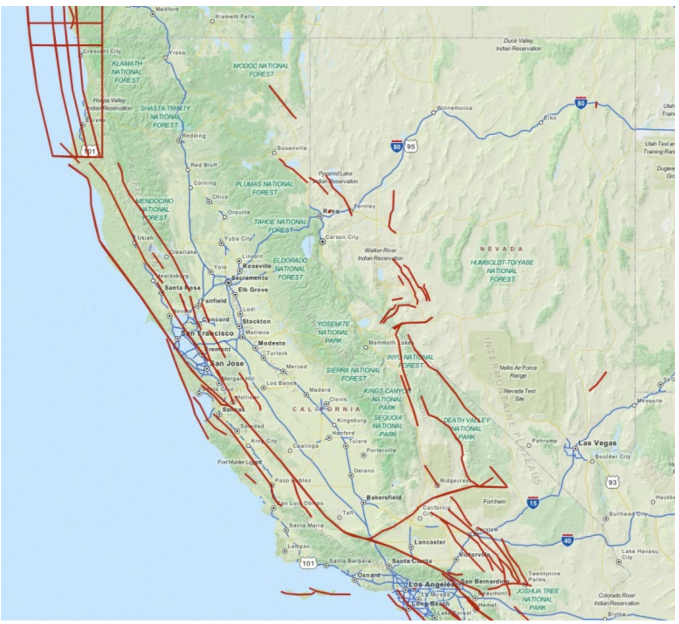
Stochastic event set – hurricane

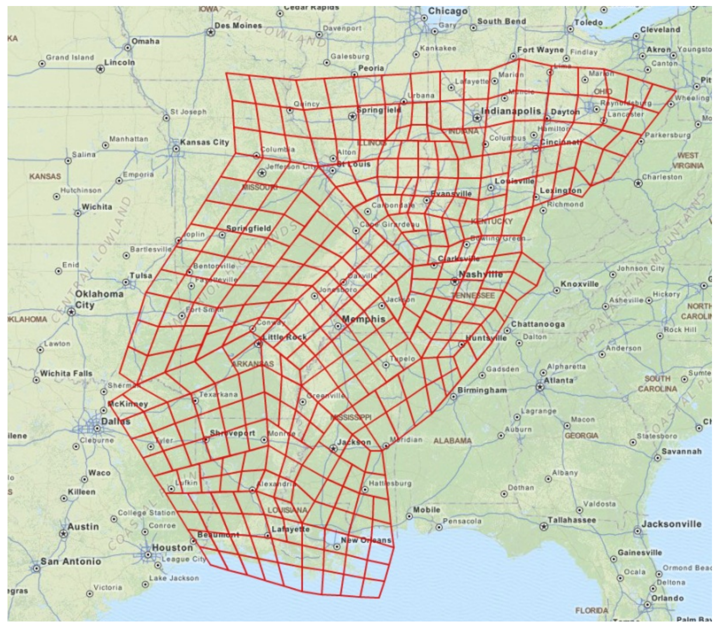
- “Universe of potential events” – Built from 100+ years of historical storm data
- Over reliance on historical data leads to:
  - Sensitivity to corrections / additions to data
  - Results not representative of future events in areas with limited historical data
- Key characteristics used to fit statistical distributions:
  - Central pressure
  - Radius of maximum winds
  - Forward speed
  - Landfall location / angle



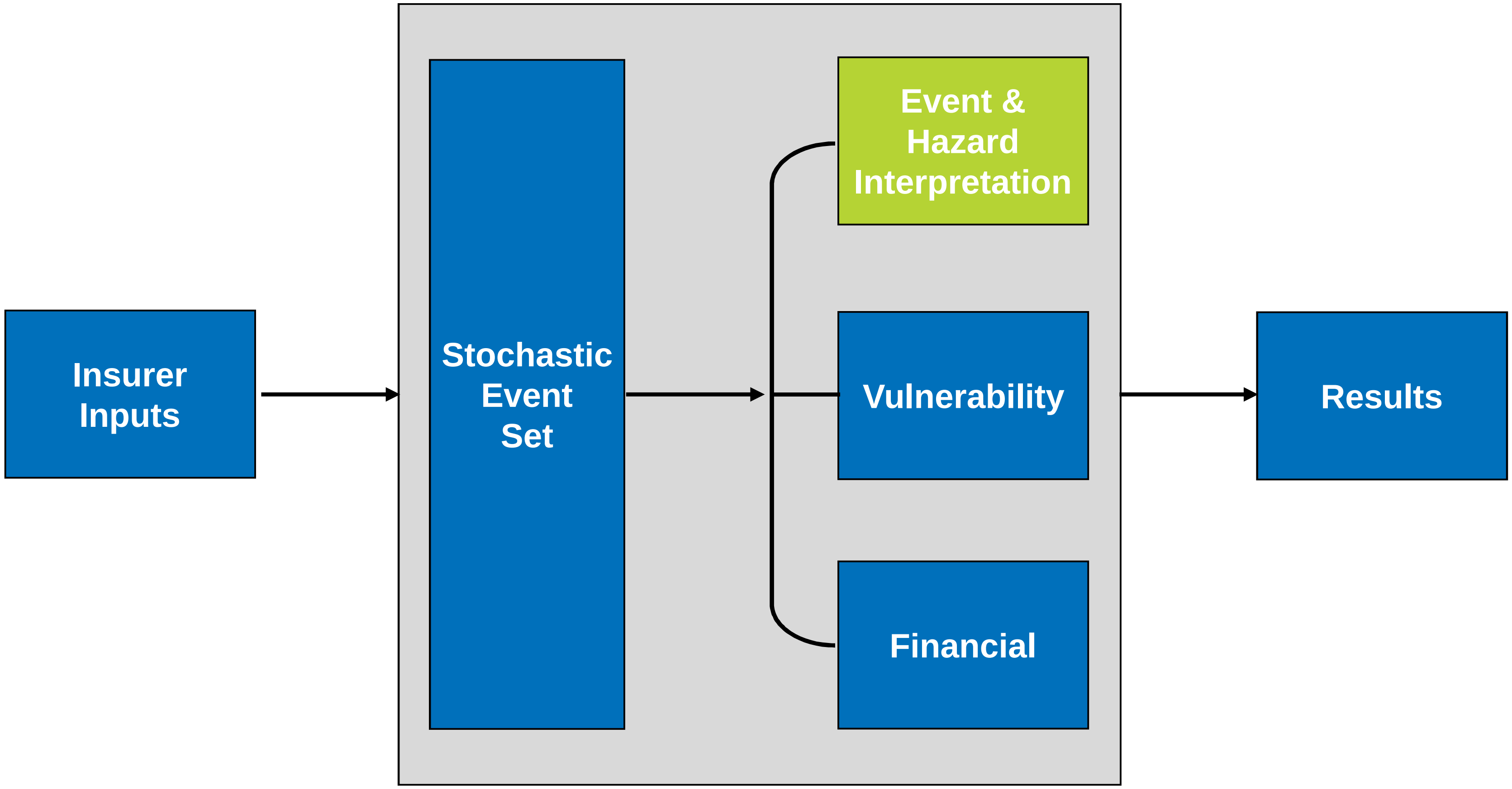
Stochastic event set – earthquake

- Stochastic event set is generated from all known line and area faults
- Incorporate variations of ruptures along the same, and neighboring, fault lines





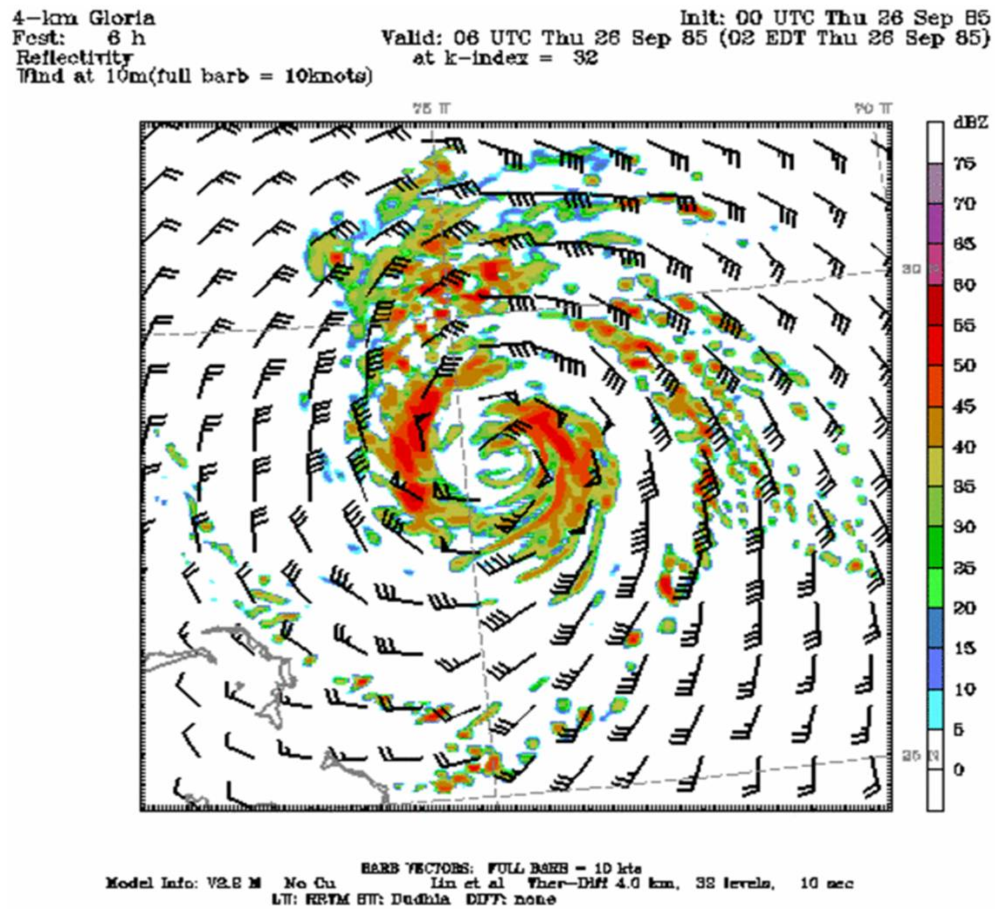
Basic model methodology



Event and hazard interpretation - hurricane

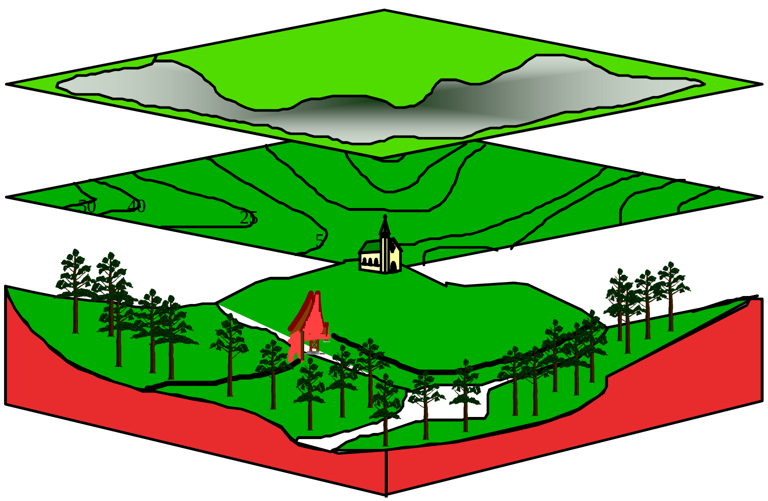
- Location wind speeds
  - Simulation of the storm's movement along the track creates a time profile of wind speeds
  - Wind speeds are calculated for each location affected by the storm over the life of the storm
  - Duration of winds as well as peak gusts are captured
  - Land friction affects local wind speeds

Time stepping directional windfield



Event and hazard interpretation - hurricane

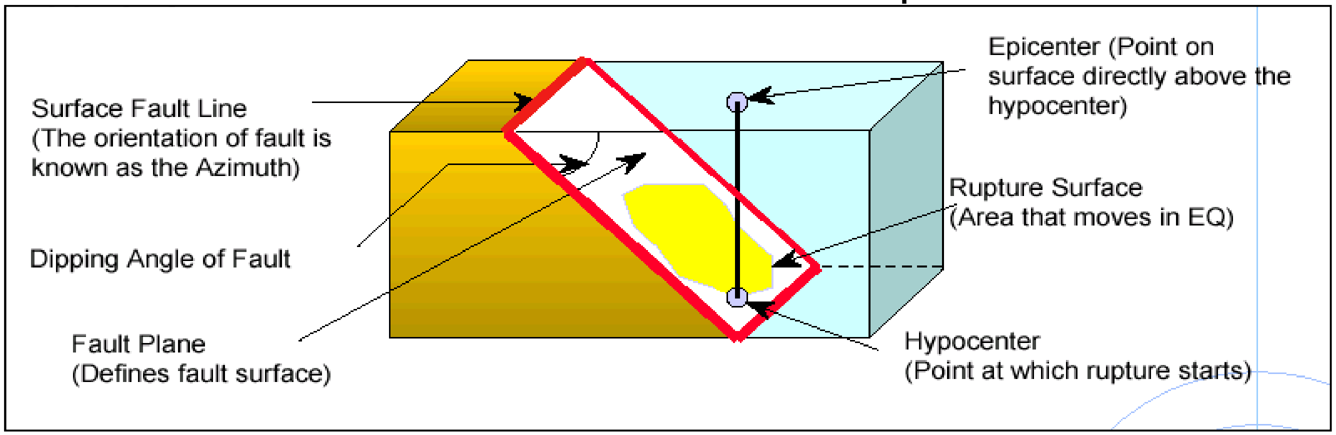
- Elements of surface roughness (land friction)
  - Topography – forest land, wetlands, water, etc.
  - Elevation
  - Land use - building density, agriculture, etc.

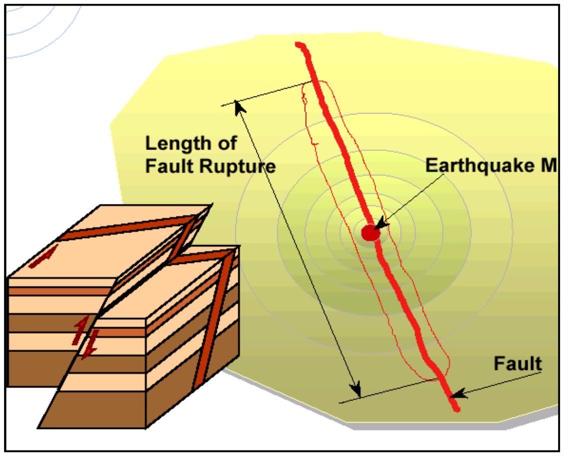


Source: NOAA

Event and hazard interpretation - earthquake

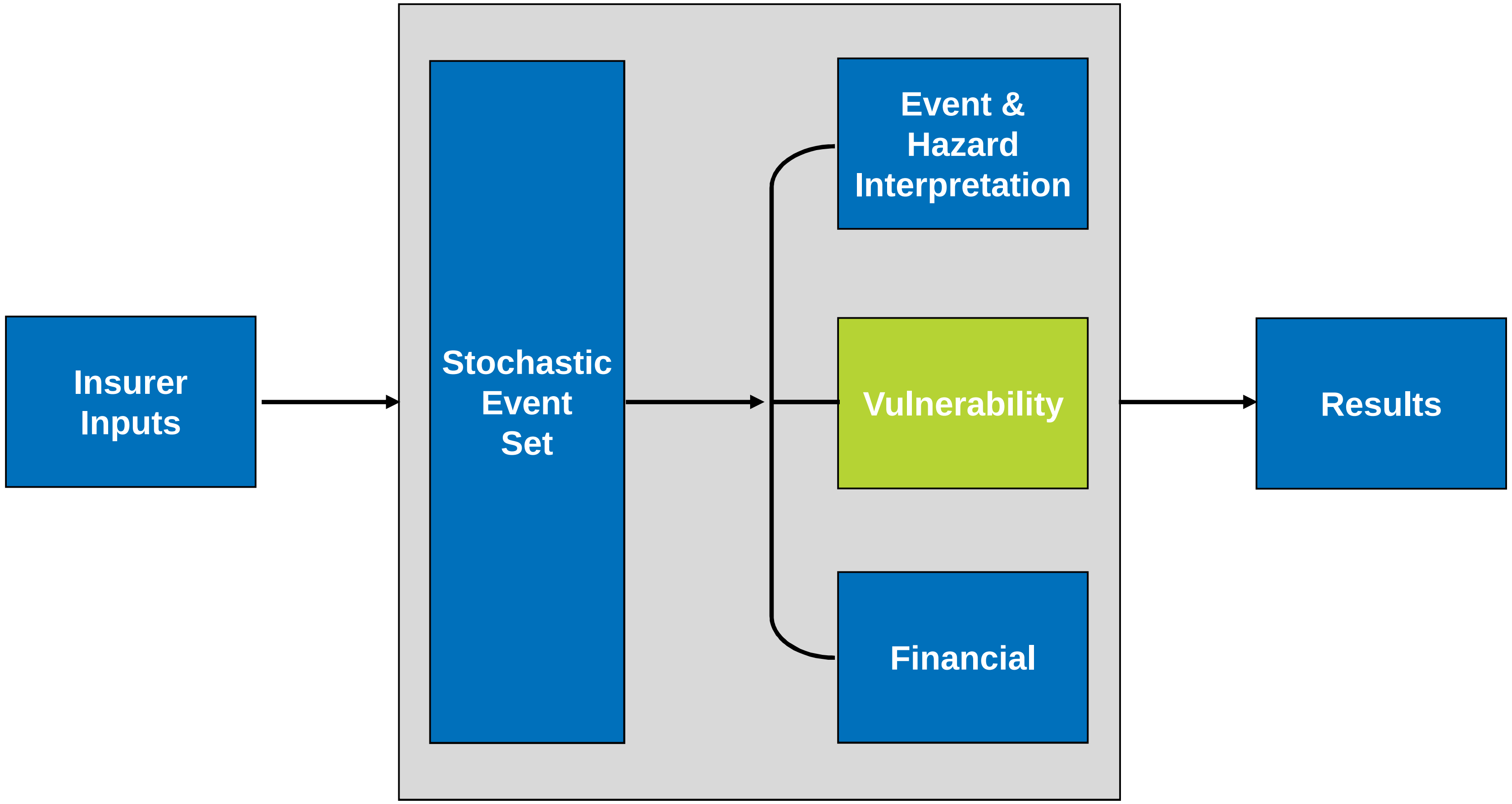
Characteristics of an earthquake





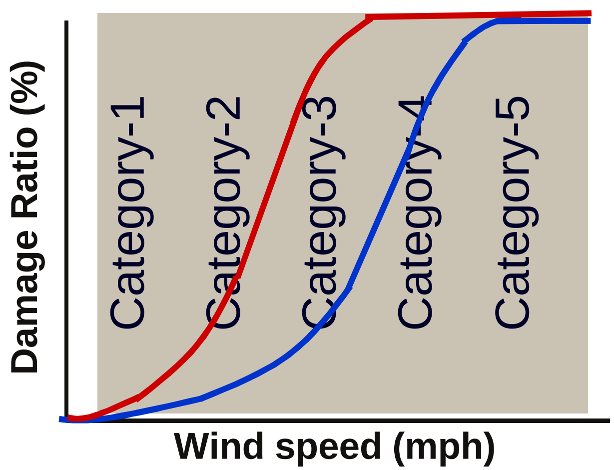
- Ground shaking "attenuates" from the source of the event and dissipates as it moves away from the source
- The distance of the attenuation is influenced by soil conditions in the areas
- The most damage does not necessarily occur at the epicenter

Basic model methodology



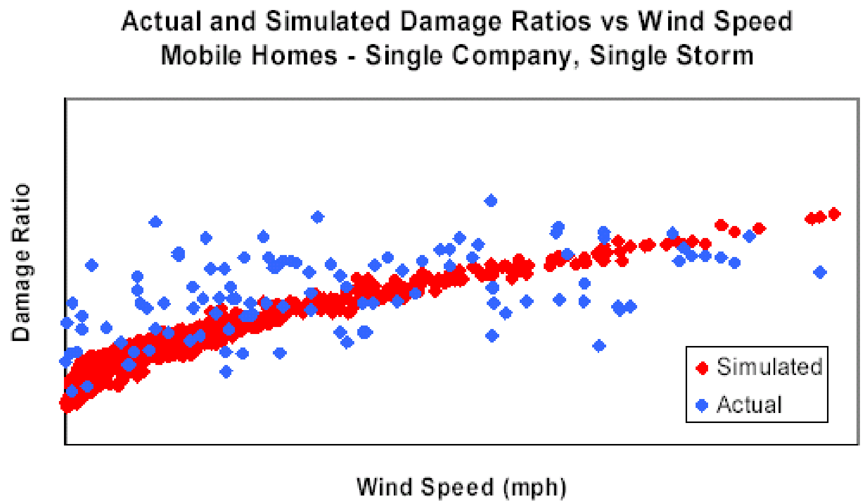
Damage and vulnerability functions

- Interaction of buildings to the local intensity
  - Building characteristics: construction, height, year built, square footage, roof type, location, value, etc.
- Expected damage expressed as a percent of the replacement cost value of the structure

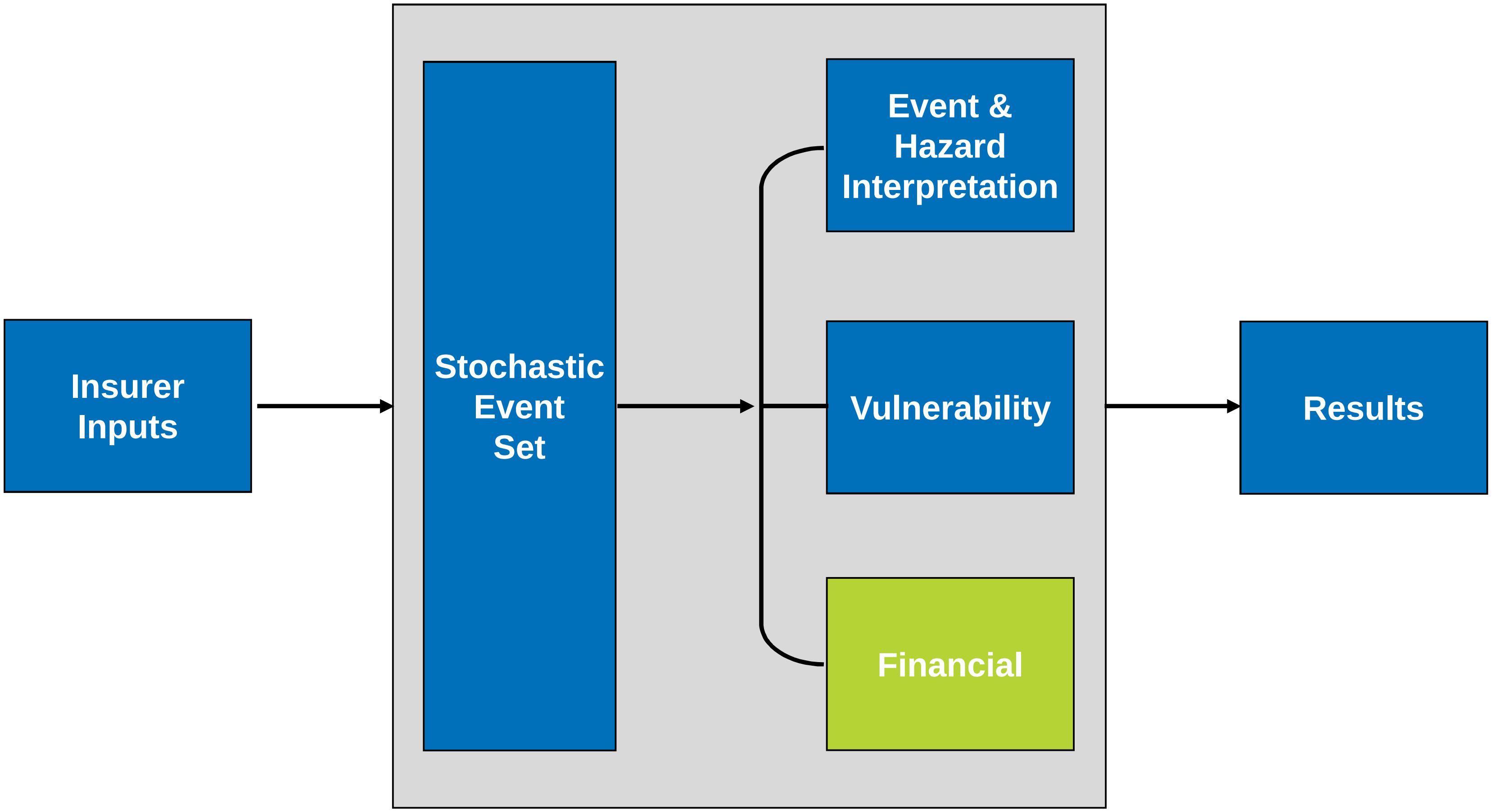


Vulnerability

- Based on four sources of information:
  - Engineering research
  - Structural tests (i.e., wind tunnels)
  - Expert opinion
  - Actual loss data

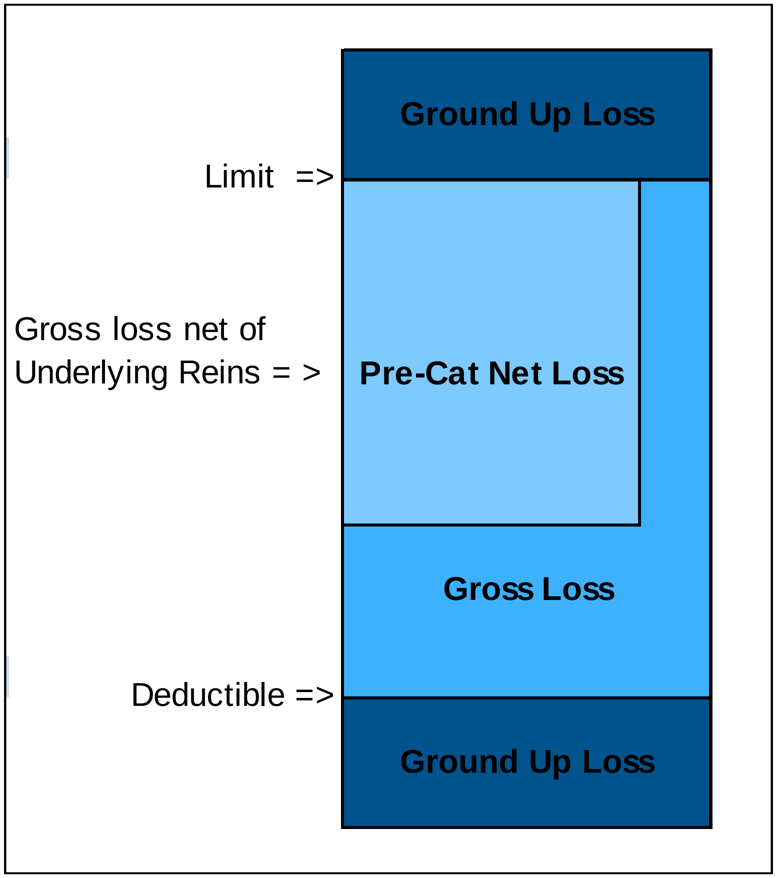


Basic model methodology



Financial perspectives

- Ground Up Loss – Full replacement cost value loss to the property prior to the application of deductibles and limits
- Gross Loss – Loss to the insurance policy after the application of deductibles, limits or co-insurance
- Pre-Cat Net Loss – Gross loss after the application of risk level reinsurance, prior to the application of catastrophe reinsurance



Uncertainty in modeling

- Primary uncertainty
  - Uncertainty due to the number or type of events that may occur
  - Whether or not an event will occur
  - Which event it will be
  - There could be none, or there could be more than one

- Secondary uncertainty
  - Uncertainty in the amount of loss

Sources of secondary uncertainty

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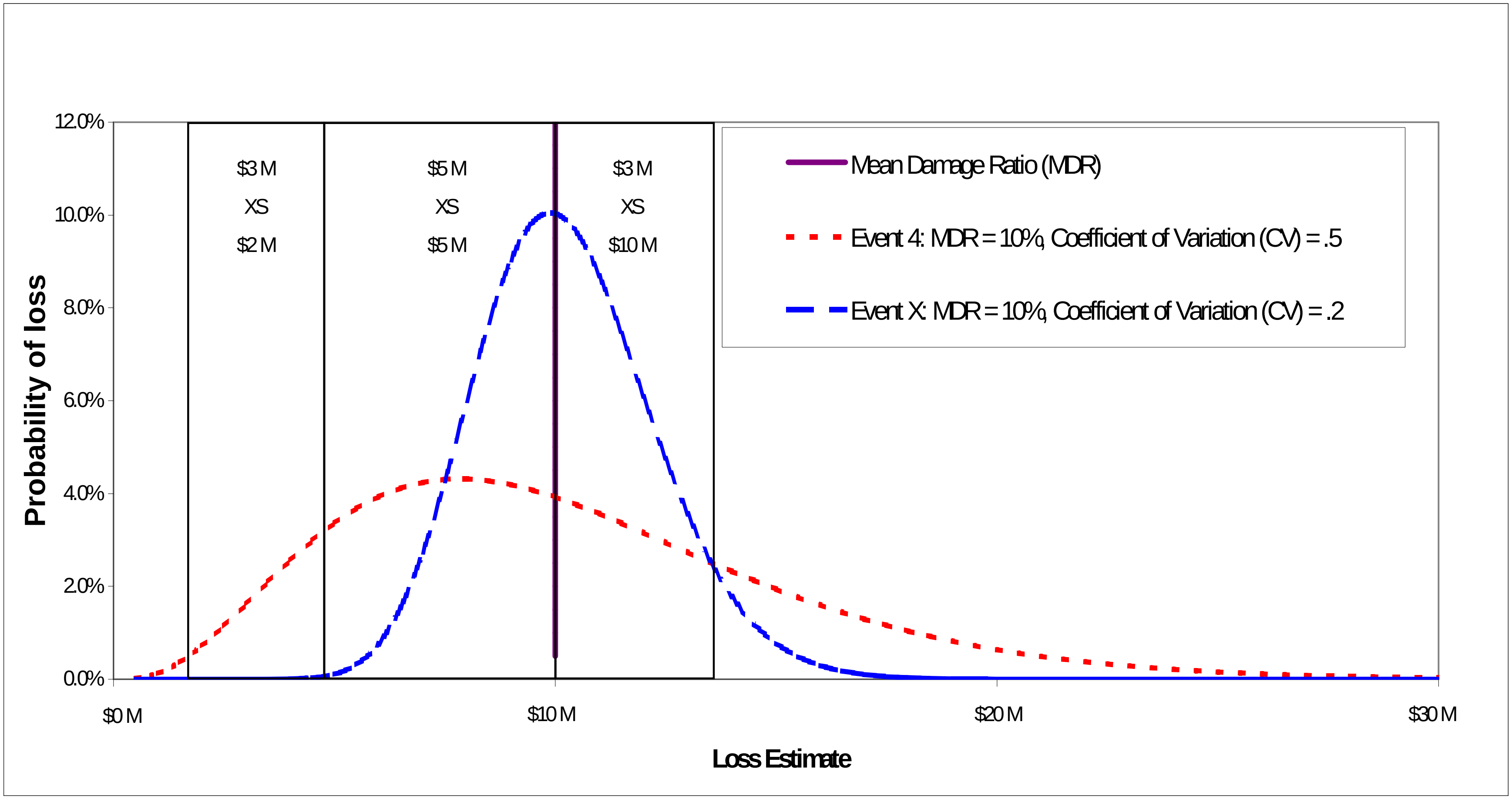
- Hazard uncertainty
- Vulnerability uncertainty
- Specification uncertainty
- Portfolio data uncertainty

1964 Ni'igata earthquake in Japan

Distribution through financial perspectives



Workers comp modeling process

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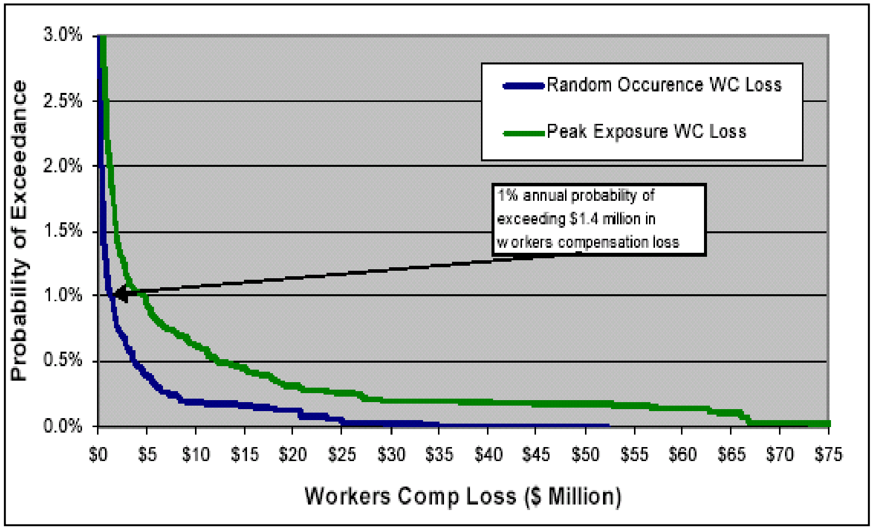
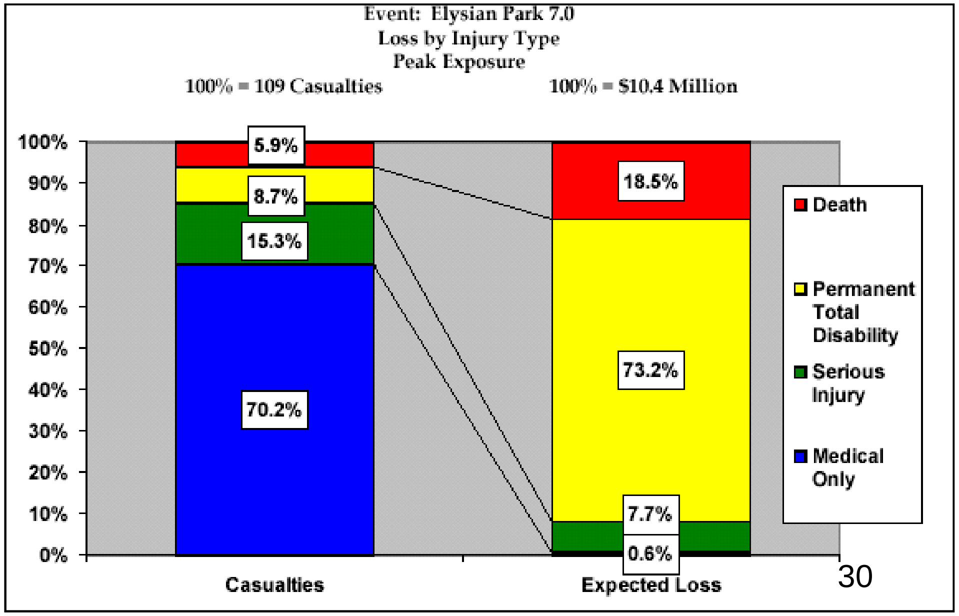
- Input Exposures
  - Number of Employees or Payroll
  - Building Information
- Apply Hazards and Engineering
  - Earthquake and Terrorism Hazards
  - Building Damage Distributions
  - Resulting Injury Distributions
- Apply Injury Cost Matrix
- Result is Loss Estimate

Workers comp modeling results

- PML, scenario, and average annual losses





Differences in model methodologies

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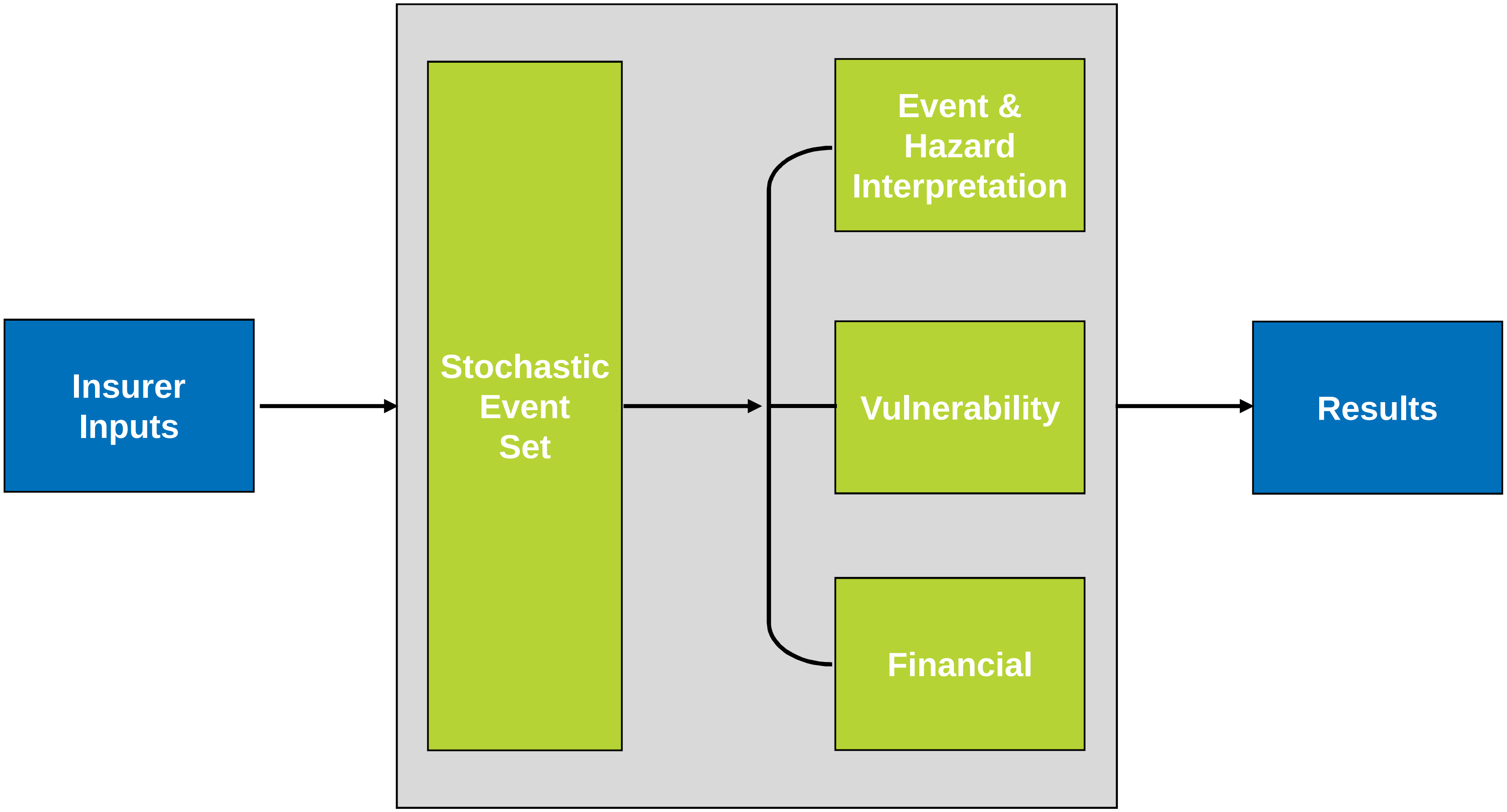
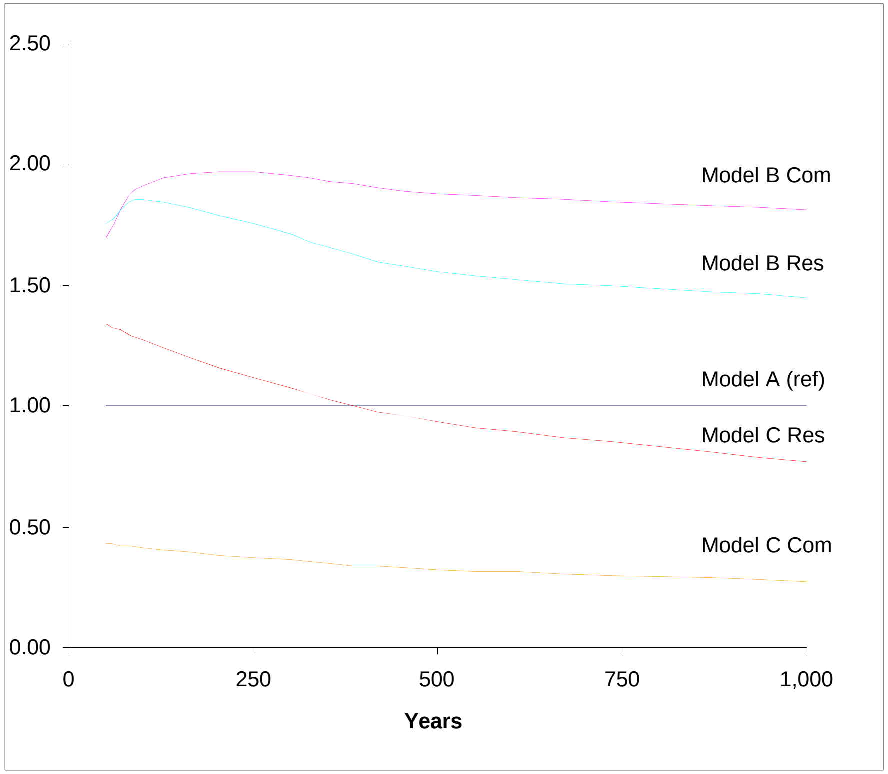


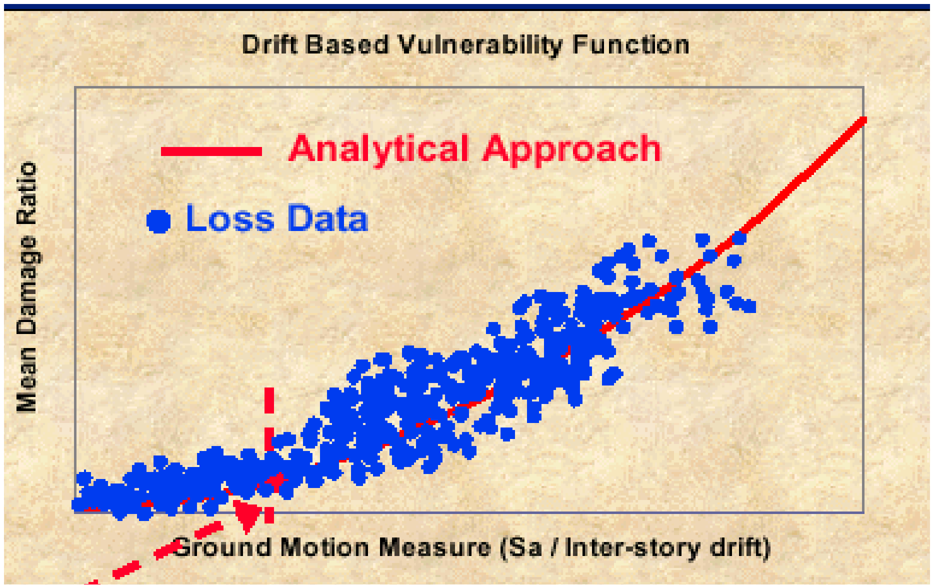
Differences in model methodologies

- Key Areas of Differences:
  - Stochastic event set generation
  - Event and hazard interpretation
  - Vulnerability functions
  - Financial calculation methodology



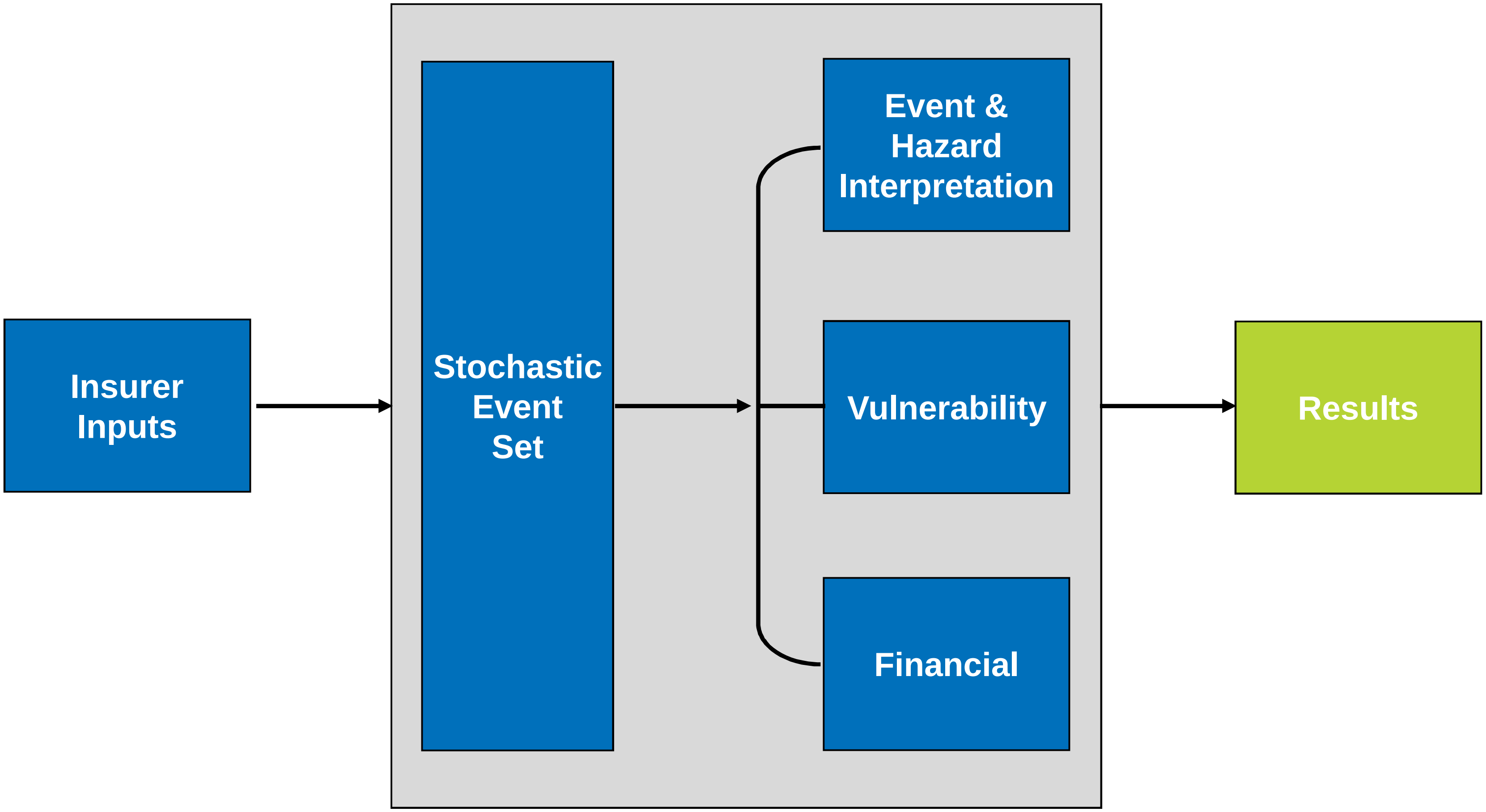
Differences in model methodologies – vulnerability functions

- Proprietary to each modeler and based on:
  - Research – engineering testing
  - Insurance loss data
  - Academic opinions



- Other factors:
  - Resolution of key characteristics and how they relate - construction definition, primary occupancy, year of construction, building height, etc.

Basic model methodology



Agenda

- Today's schedule
  - Modeling methodologies
  - **Understanding and applying model output**
  - Data management and procedures

Model output – Average Annual Loss (AAL)

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- What is the expected loss from catastrophes each year?

Average Annual Loss

- Represents the long run expected annual loss to the property or account
  - (Event Losses * Event Occurrence Rate)

Model output – key loss estimates

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Modeled Gross Loss ($000)							
		Hurricane		Severe Storm		Combined Perils	
Probability of Loss	Return Period	Vendor 1	Vendor 2	Vendor 1	Vendor 2	Vendor 1	Vendor 2
0.10%	1,000	$213,841	$139,044	$126,669	$147,531	$228,181	$176,596
0.20%	500	$148,716	$111,116	$97,288	$122,791	$173,183	$146,196
0.40%	**250**	**$97,750**	**$70,468**	**$73,740**	**$98,595**	**$120,720**	**$117,184**
1.00%	**100**	**$50,976**	**$33,443**	**$48,000**	**$73,202**	**$74,397**	**$83,598**
2.00%	50	$27,190	$19,326	$33,101	$50,480	$49,297	$60,286
Average Annual Loss		$2,652	$2,013	$15,885	$17,874	$18,537	$19,887
Standard Deviation		$15,369	$10,092	$14,099	$18,600	$20,908	$21,104
Coefficient of Variation		5.8	5.0	0.9	1.0	1.1	1.1

- Probabilistic approach – likelihood of loss magnitude
- "PML" = Probable Maximum Loss
- PML curves are not additive!
- Can be peril-specific, vendor-specific, or blended

Model output – catastrophe layer statistics

Catastrophe Layer Statistics ($000)							
Layer Name	Layer Amount (Limit xs Retention)	Percent Covered	AAL to Layer (Pure Premium)	Standard Deviation of Layer	Rate On Line (AAL / Limit)	Return Period of Entry	Return Period of Exit
Retention	$10M xs $0	100%	$11,955	$42,679	119.6%	1	11
Cat XOL 1	$15M xs $10M	100%	$639	$3,674	4.3%	11	50
Cat XOL 2	$15M xs $25M	100%	$210	$1,506	1.4%	50	103
Cat XOL 3	$25M xs $40M	100%	$158	$1,499	0.6%	103	259
Total Cat Program	**$55M xs $10M**	**100%**	**$1,007**	**$7,911**	**1.8%**	**11**	**259**
Over Limit	• xs $65M	100%	$172	$1,982		259	•

- AAL • Pure Premium
- Used in pricing reinsurance program
- Likelihood of loss affecting / exhausting program limits

Model Output ($000)		
Probability of Loss	Return Period	Pre-Cat Net Loss
0.10%	1,000	$120,050
0.20%	500	$88,003
0.40%	250	$57,443
1.00%	100	$39,210
2.00%	50	$25,050
4.00%	25	$16,230
10.00%	10	$9,680
	AAL	$13,134

Practical applications for modeled estimates

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- Modeling output used in (re)insurance:
  - Modeled average annual losses used in policy rating / pricing metrics (“Cat Load”)
  - Estimated large loss potential – used in reinsurance program design / decision making / capital allocation
  - Risk driver analyses used to develop strategies for improved catastrophe management (optimization)
  - Identify involuntary assessment potential (wind pools, etc.)

Potential issues with modeled estimates

- Major changes to models can influence rates and upset underwriting strategies
- Lack of historical claims data leads to significant uncertainty in some perils and geographic areas
- Poor quality input data leads to poor quality results
- Generally better for long-term management than for individual event estimates

Agenda

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- Today's schedule
  - Modeling methodologies
  - Understanding and applying model output
  - **Data management and procedures**

Risk evaluation consultant

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- More than just modeling -
- A cornerstone to the property catastrophe reinsurance transaction
  - Product structure, pricing & consulting
  - Experts in natural perils, data management & GIS

Modeling process

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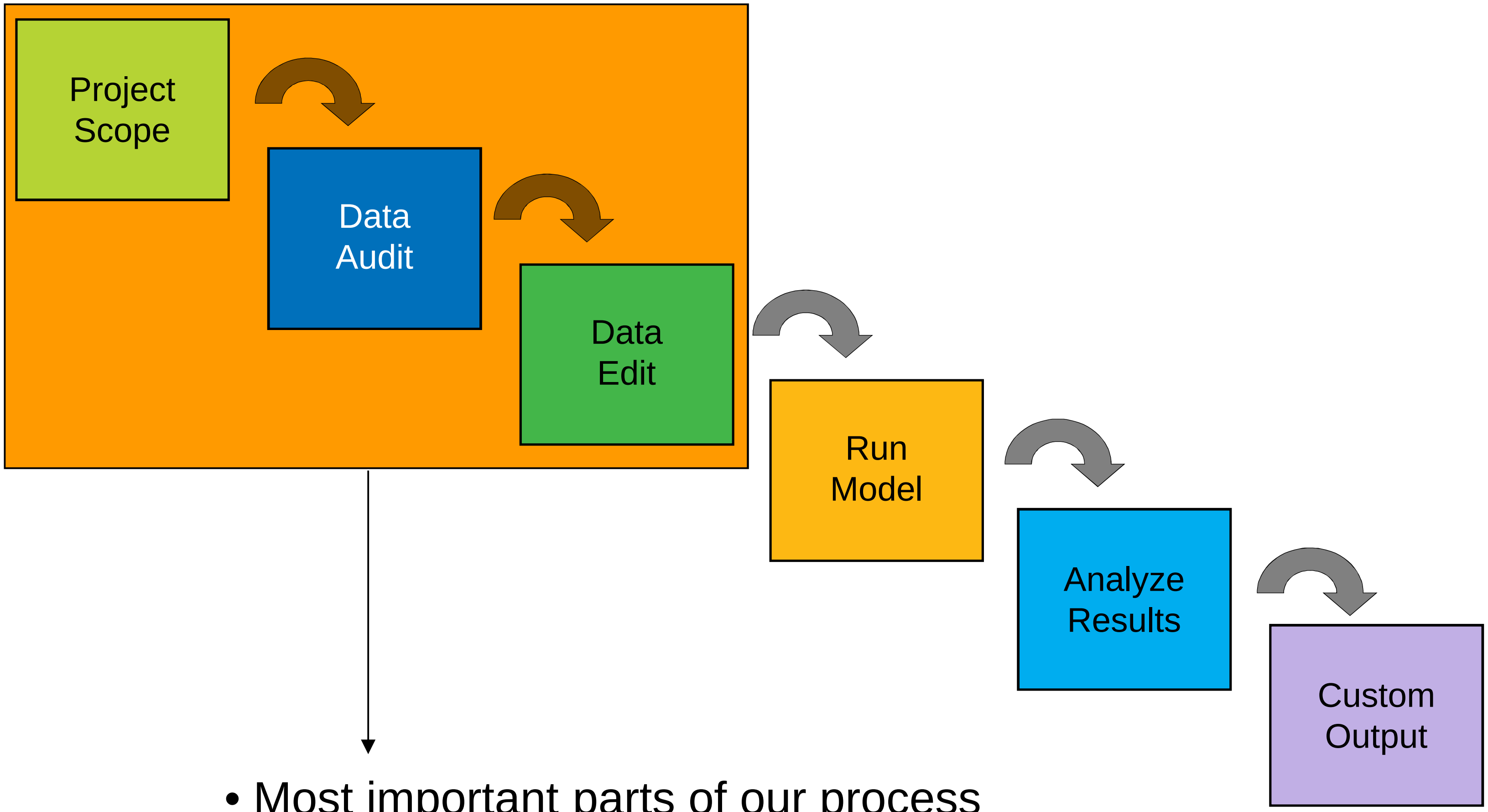

- Most important parts of our process
- Proper time spent here helps limit rework

Questions or Comments?

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- (b) Notwithstanding the foregoing, AIR hereby agrees that disclosure of the CLASIC/2 Analysis to insurance regulators and disclosure, in confidence, of the CLASIC/2 Analysis by the Client to reinsurers and auditors is exempt from the prohibitions of 1(a) above; provided that, in the event of any such disclosure, the Client shall clearly acknowledge in writing that AIR owns the exclusive right and title to the CLASIC/2 Analysis and the methods employed to develop the Analysis.
- (c) The Client shall not alter or remove any copyrights, trade secret, patent, proprietary and/or other legal notices contained on or in copies of the CLASIC/2 Analysis. The existence of any such copyright notice on the CLASIC/2 Analysis shall not be construed as an admission, or be deemed to create a presumption, that publication of such materials has occurred.
- (d) The Client shall not by virtue of this Agreement, have any right of access to AIR's software, databases, technical or proprietary information or other property, except to the extent otherwise specifically provided herein.
- (e) The Client understands and hereby acknowledges, that (i) the information contained in the CLASIC/2 Analysis consists of estimates and that the CLASIC/2 Analysis is intended to serve only as one of several sources of information for estimating potential losses from certain catastrophes and (ii) no responsibility is or shall be assumed or implied by AIR for loss or damage to the Client or others for any adverse results experienced in utilizing the CLASIC/2 Analysis.
- (2) The Client agrees, for the benefit of AIR and Willis Re Inc., that no responsibility is or shall be assumed or implied by AIR or Willis Re Inc. for loss or damage to the Client resulting from inaccuracies contained therein nor shall AIR or Willis Re Inc. be liable to the Client or others for any adverse results experienced in utilizing the CLASIC/2 Analysis.

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