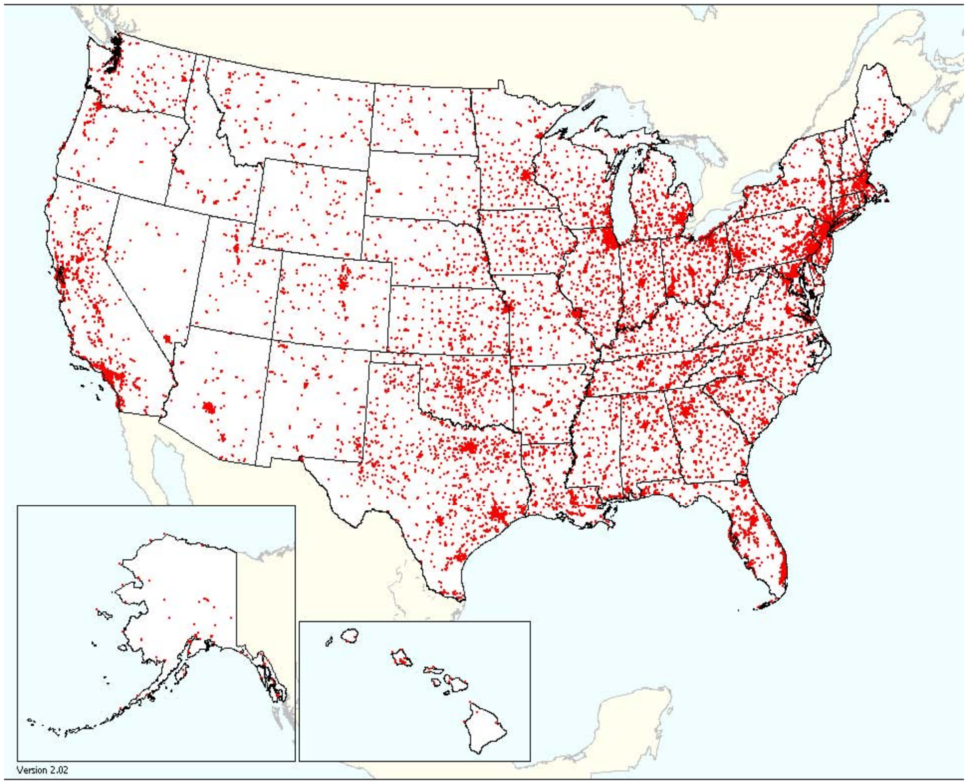
Terrorism

Terrorism Model: Possible Future Attacks Where They Could Occur

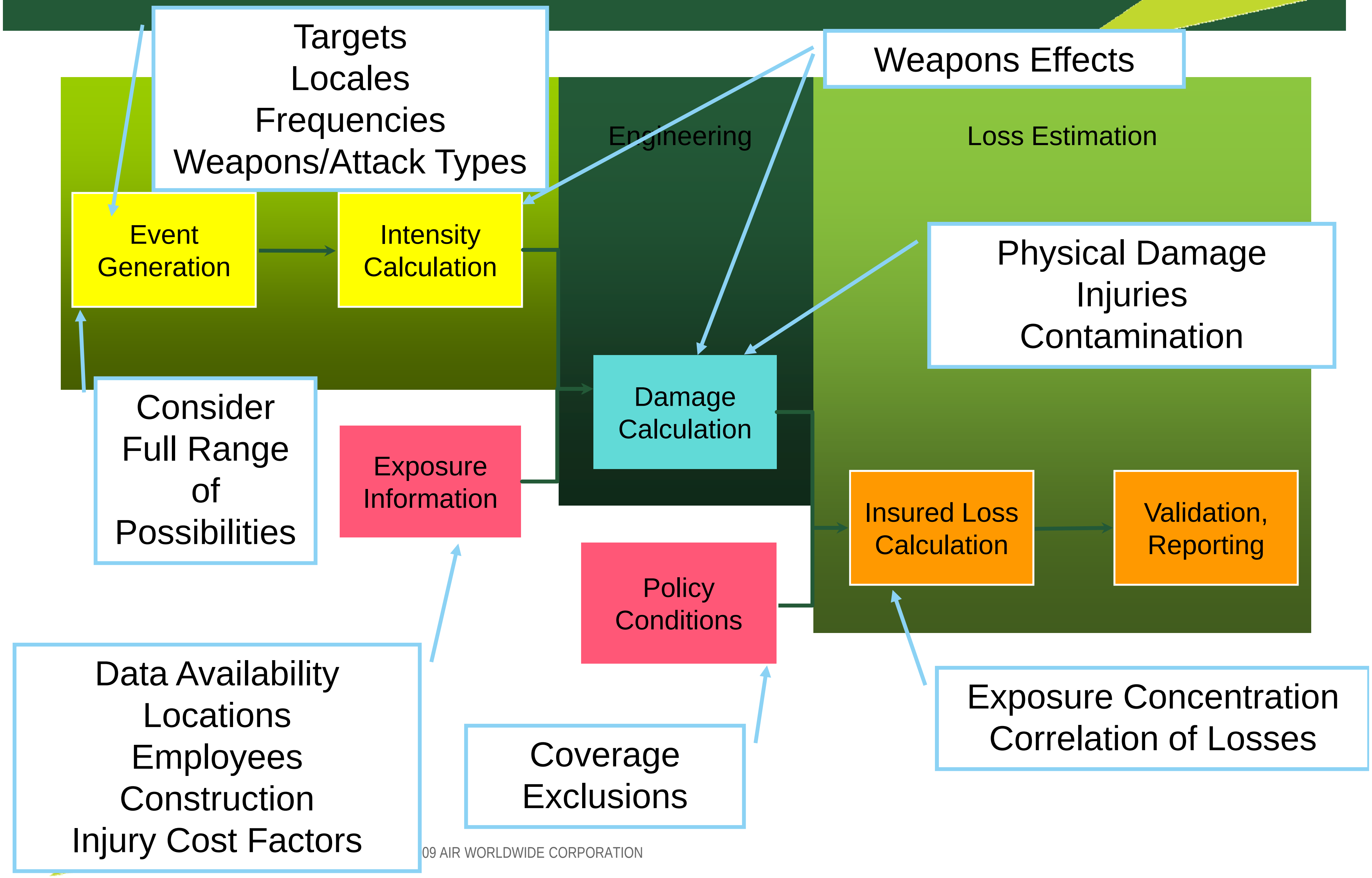
- Commercial facilities
  - Prominent buildings
  - Corporate headquarters
  - Transportation facilities
  - Chemical plants
  - Energy facilities
  - Retail centers and malls
  - Hotels and casinos
  - Amusement parks and sports venues
- Government facilities
  - Federal office buildings and courthouses
  - Embassies
  - State capitols
- Educational, medical, and religious institutions, etc.



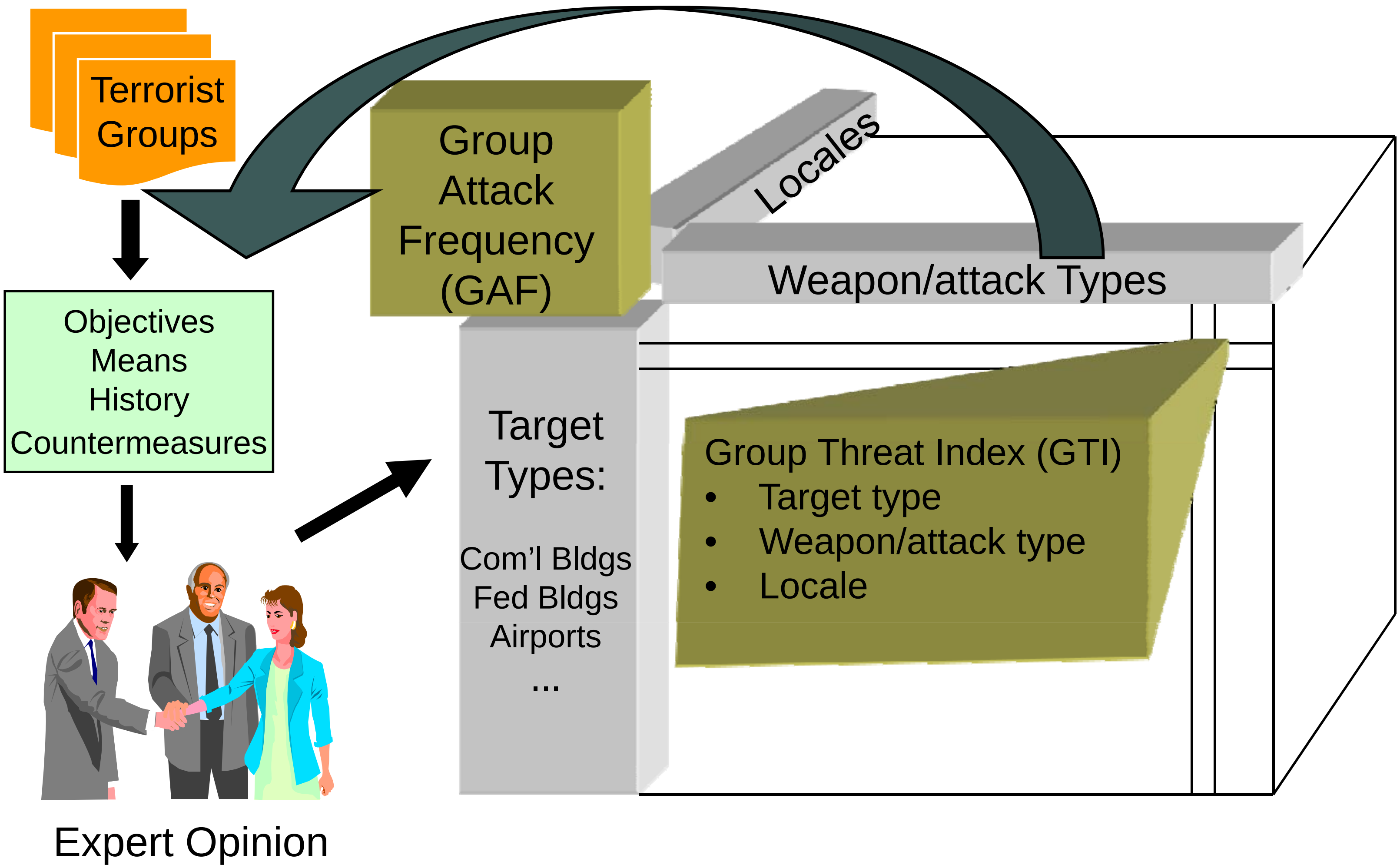
Key Questions to be Answered by the Terrorism Model

- Who?
- Where?
- How?
- How much?
- How often?

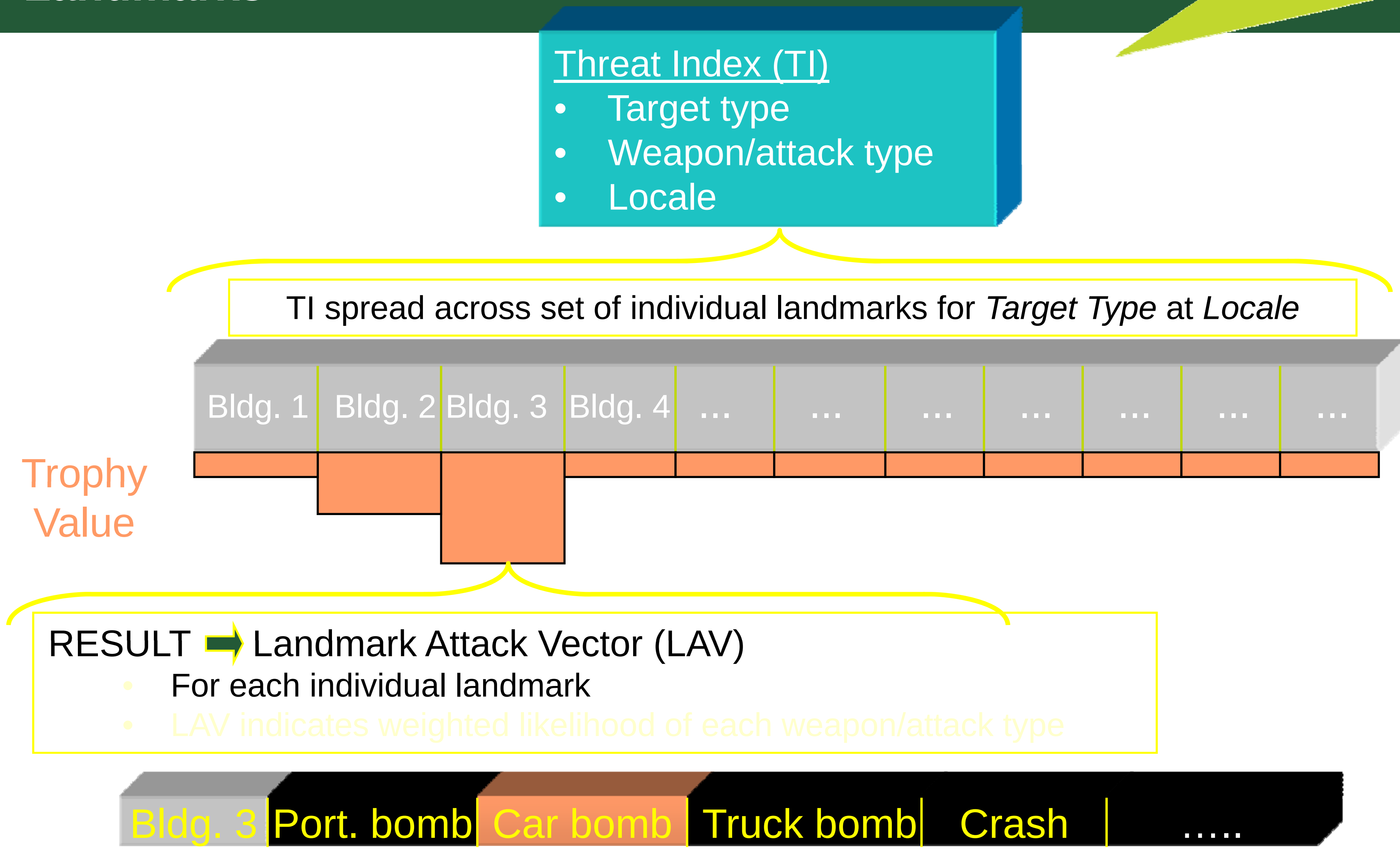
Components of Catastrophe Models - Terrorism Challenges



Delphi Method for Development of Frequency and Severity Updates



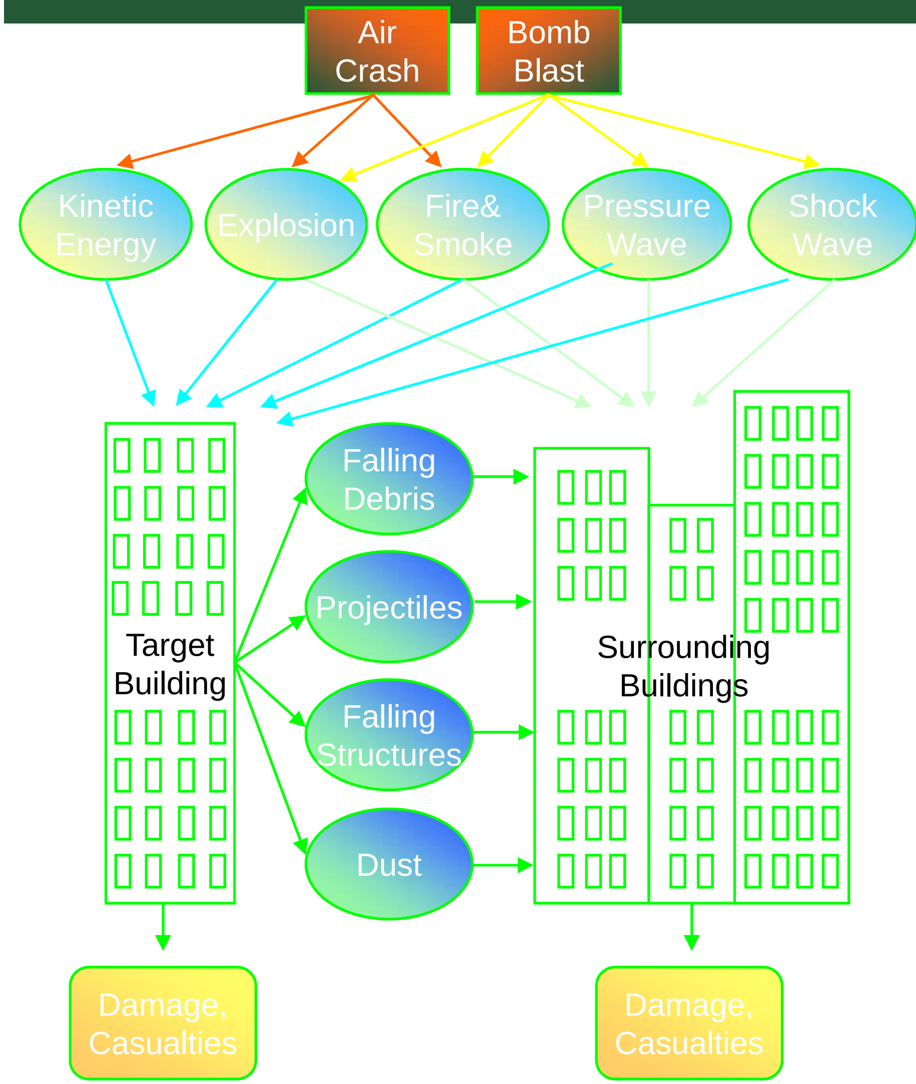
Threat Index (TI) is Spread across Individual Landmarks

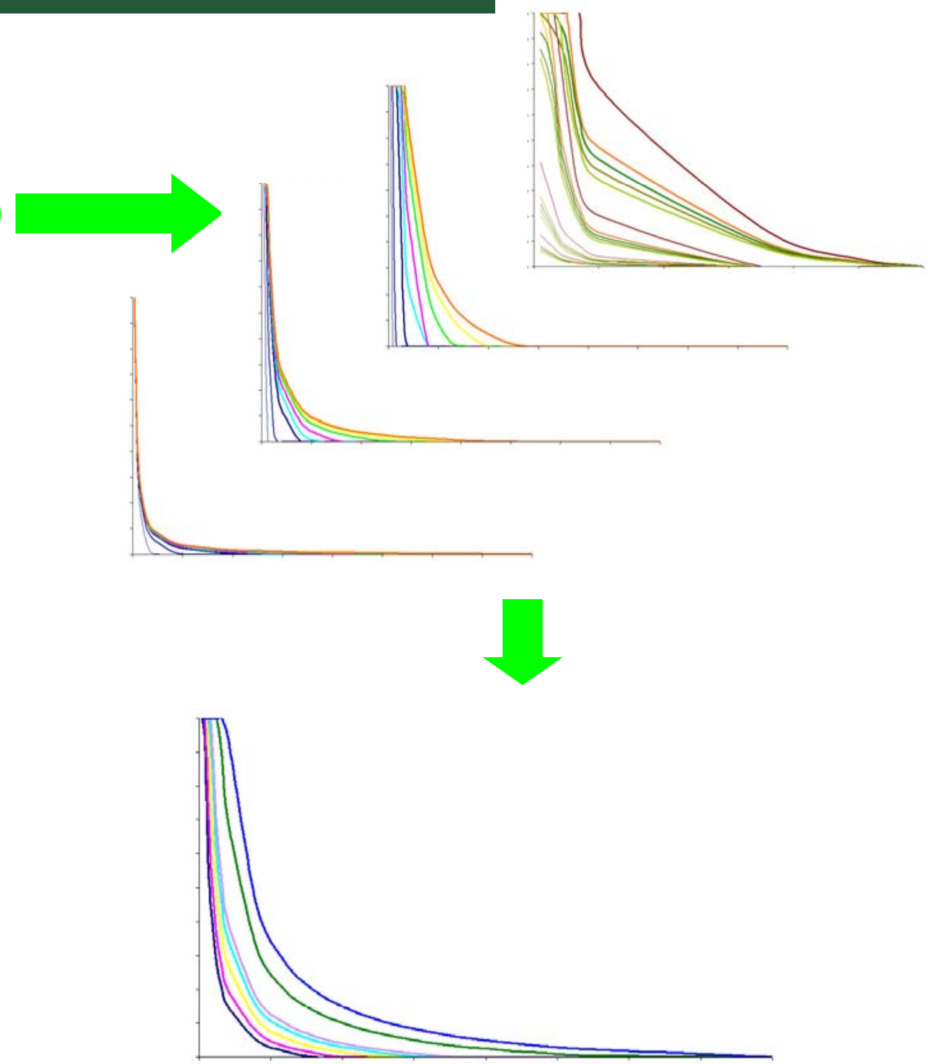


Weapon Intensity and Damage

- Bomb Blast
- Air Crash
- Chemical
- Biological
- Radiological
- Nuclear

Damage and Casualty Estimates Consider Multiple Effects on the Target and Surrounding Buildings





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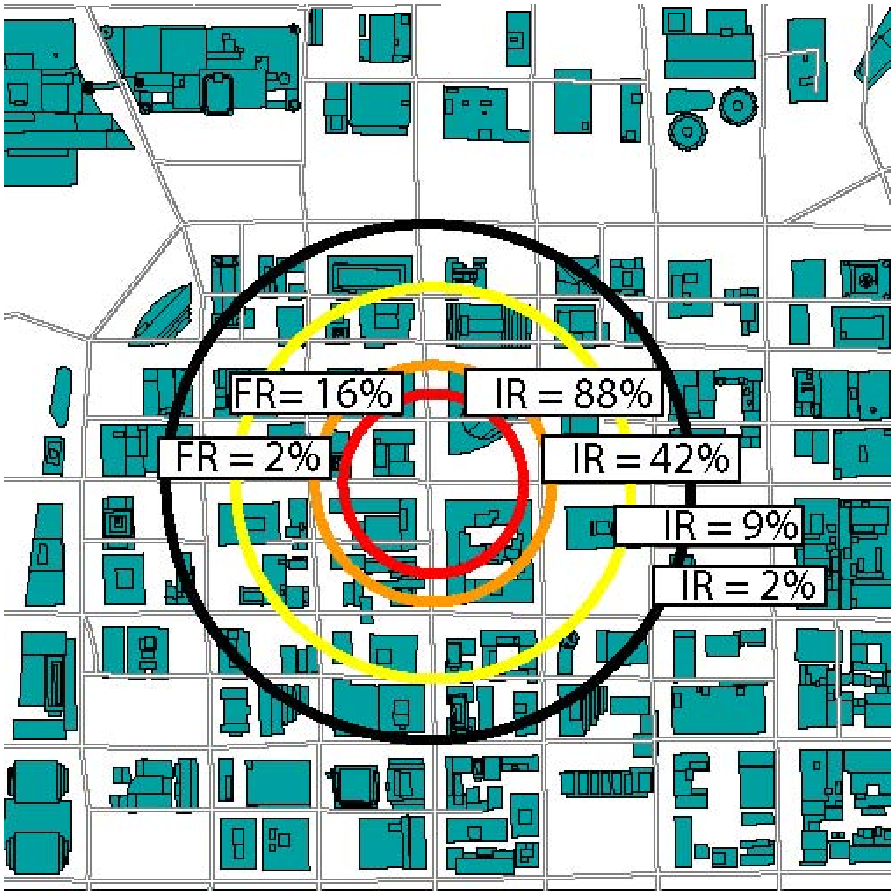
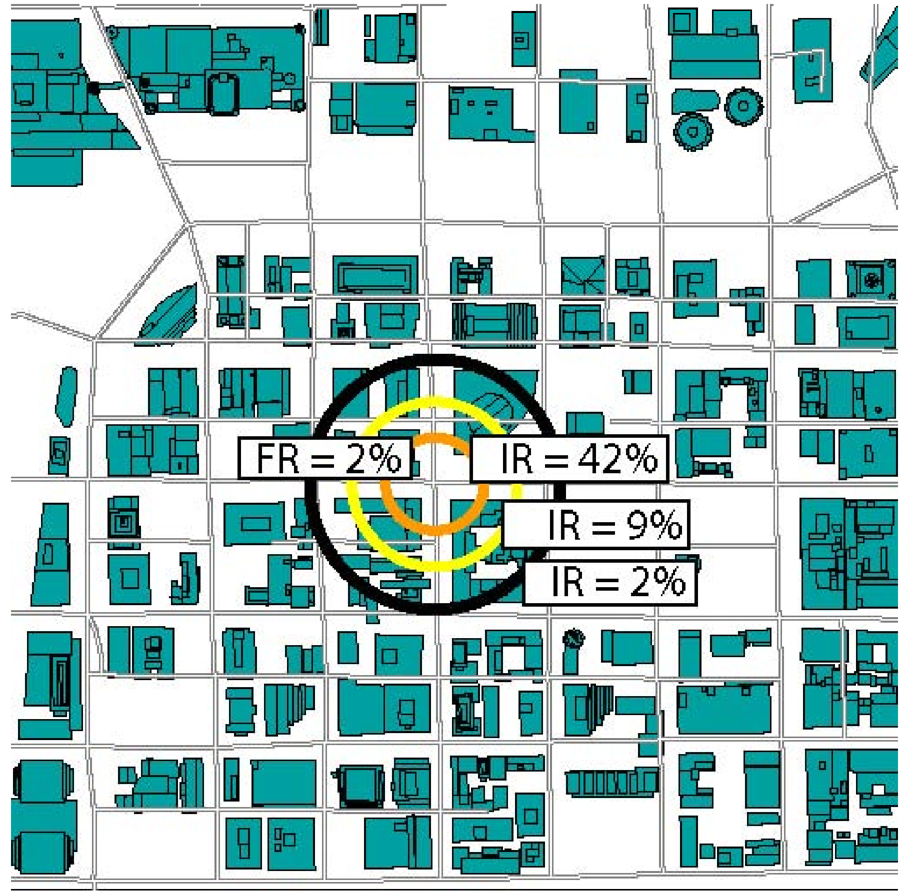
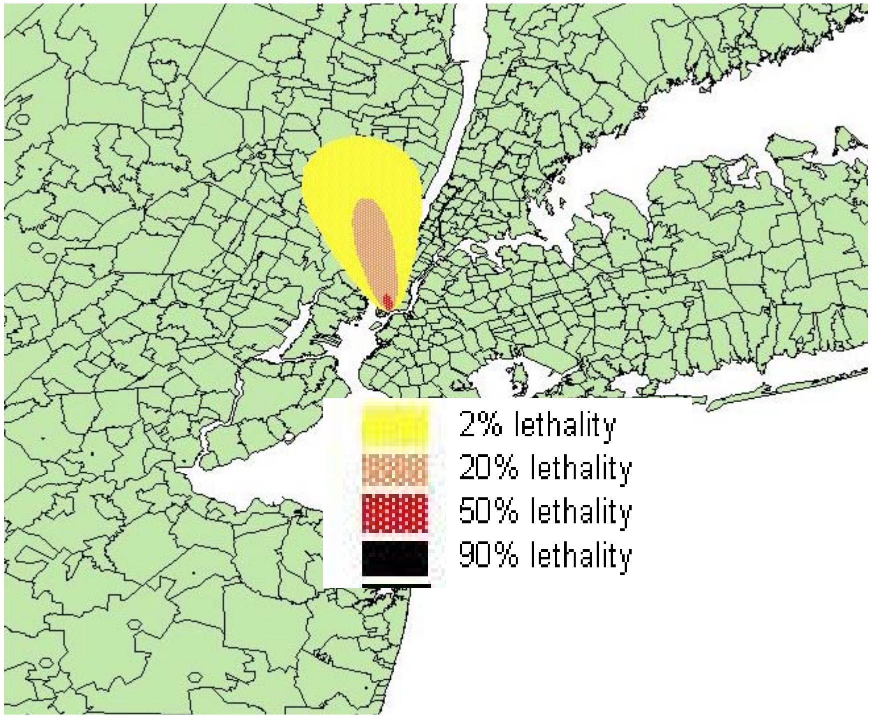
Injury and Fatality Rates Associated with Damage Contours





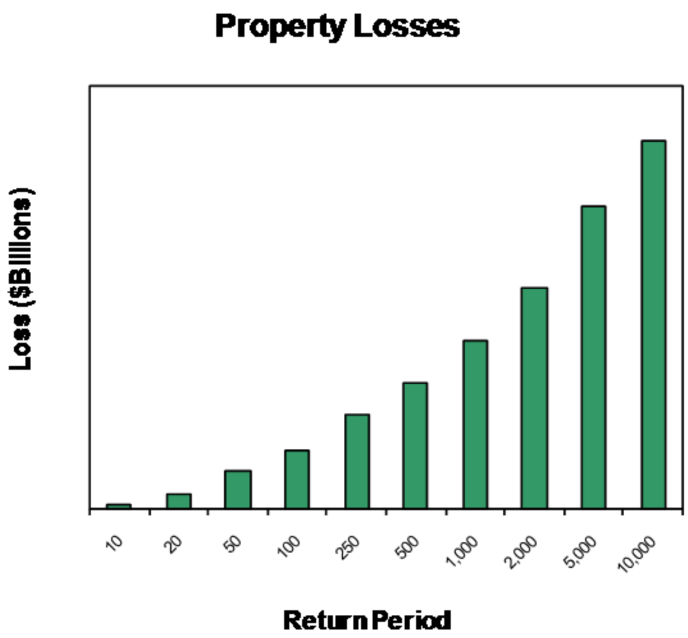
Use of DoD's Hazard Prediction and Assessment Capability (HPAC) Model for NBC

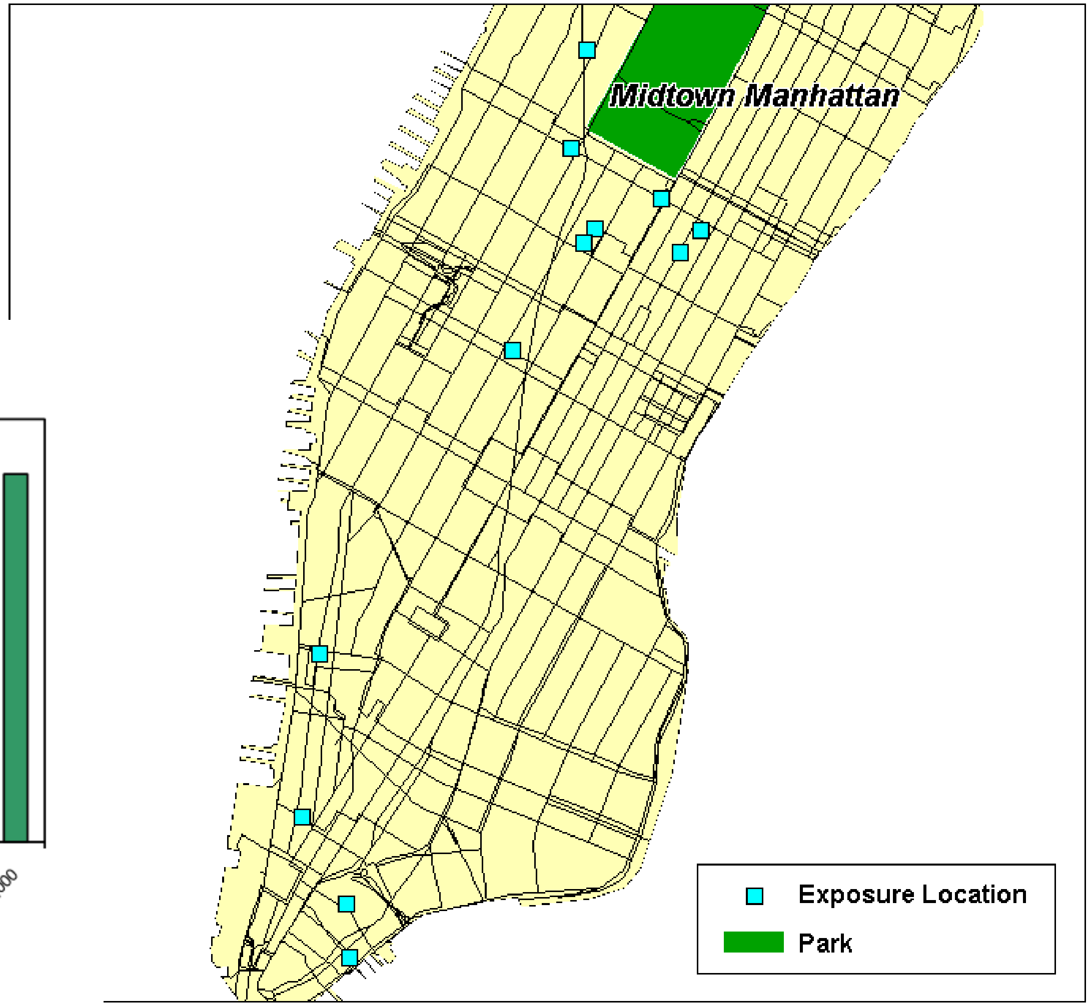
- Full spectrum of NBC weapons
- Accurately predicts the effects of hazardous material releases
  - Contamination
- Embedded climatology and historical weather data
- Terrain data and supporting wind-flow models calculate the local winds field



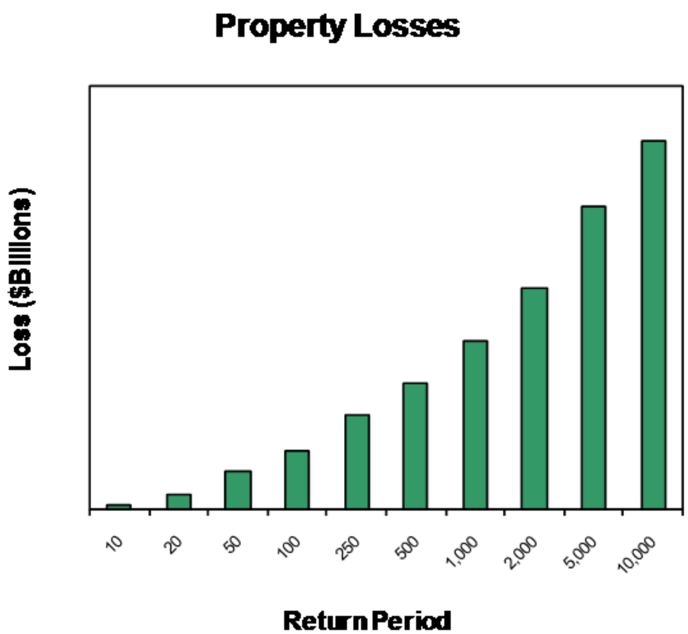
Medium anthrax attack

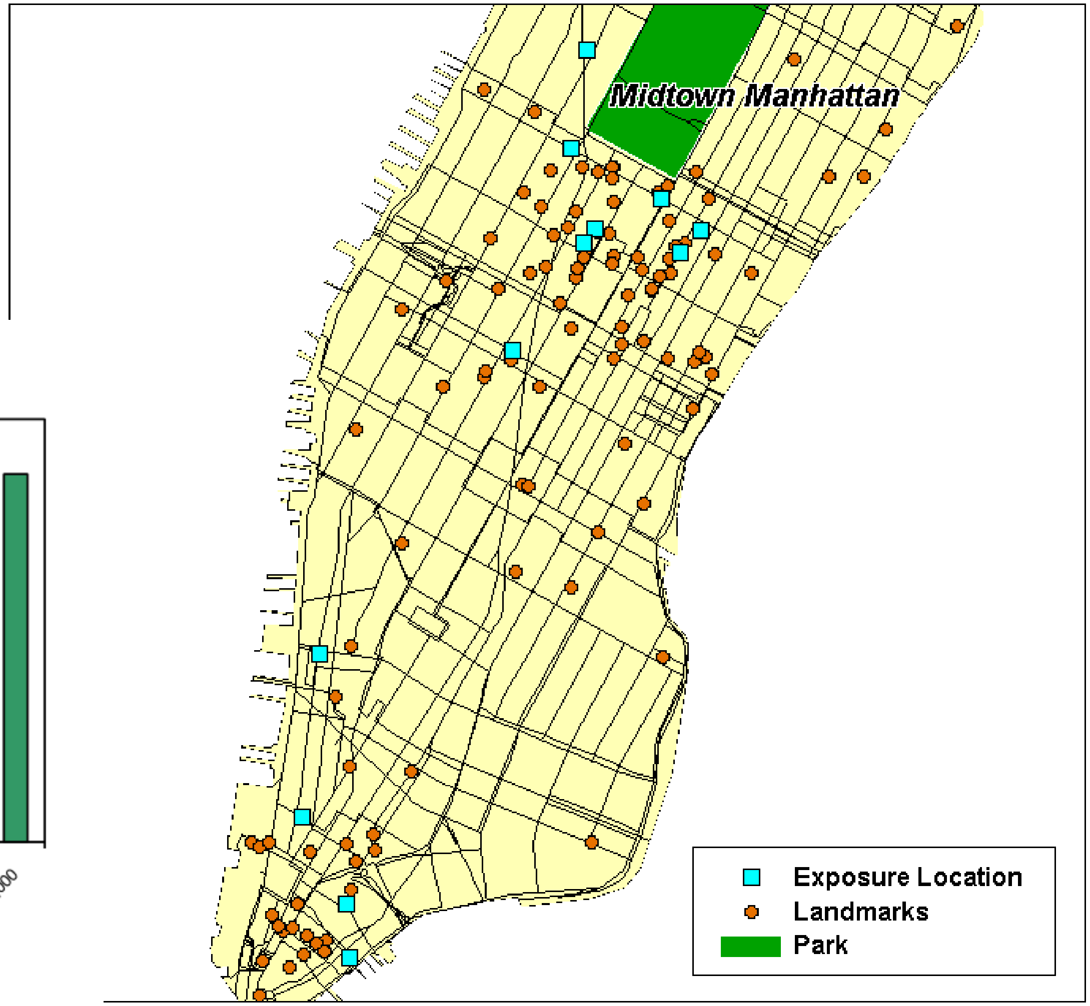
Exceedance Probability Curve Results





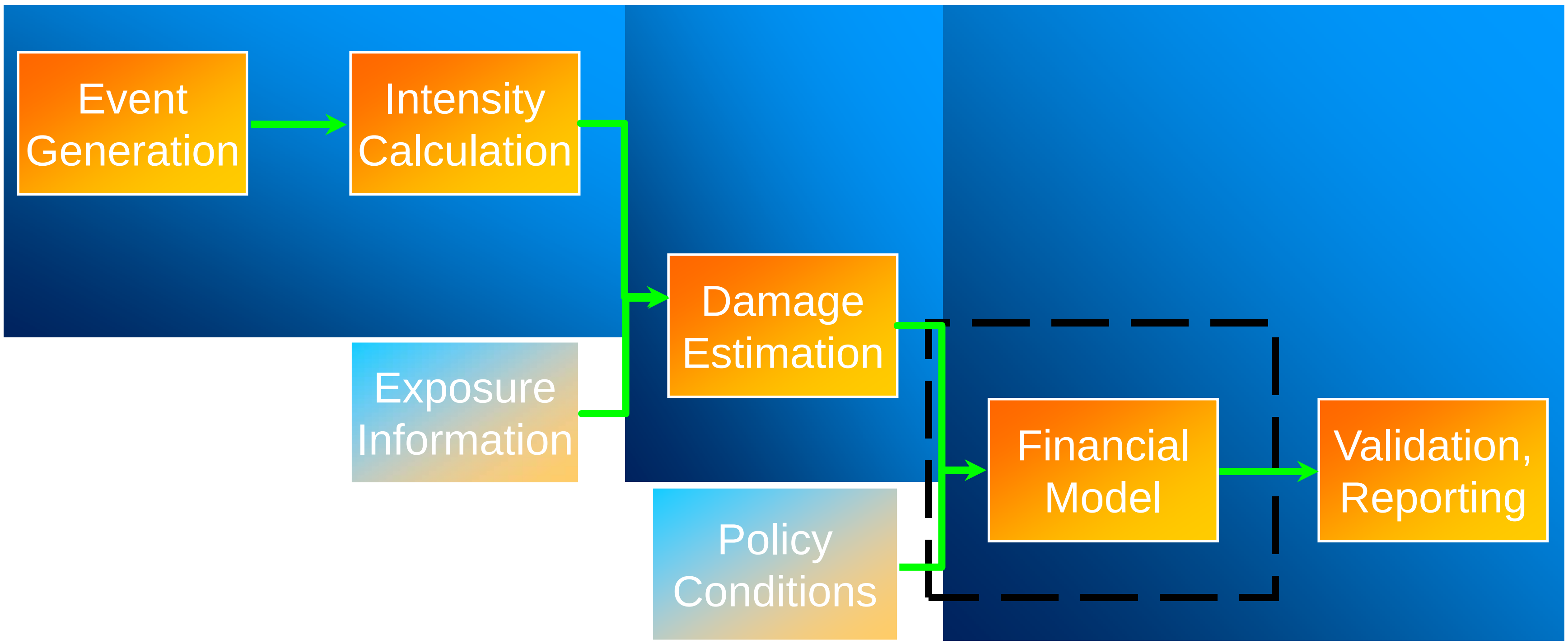
Analysis Conducted Against Each Landmark





Financial Model

Financial Model



What is the Purpose of the Financial Model?

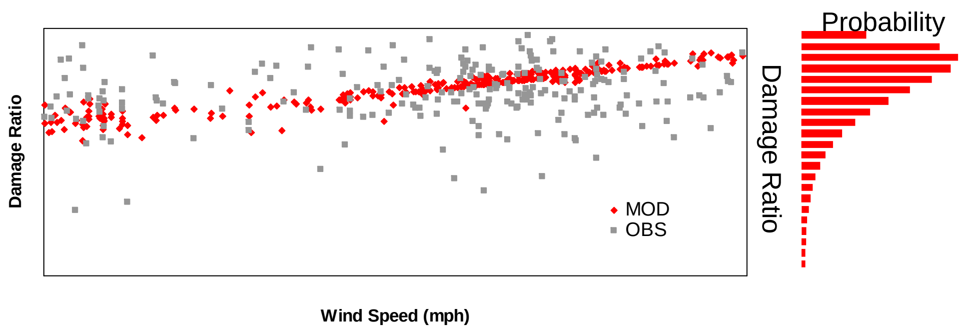
- The financial model allows users to estimate the losses to contracts that have been established to cover catastrophic events
  - Users include insurers, reinsurers, investors, other financial institutions
  - Contracts may cover individual risks, groups of risks, or portfolios of risk
- The financial model can be expected to
  - Allow users to assess contract losses from catastrophic events
  - Provide estimates of the range of losses that could occur
  - Provide input into a framework for managing risk

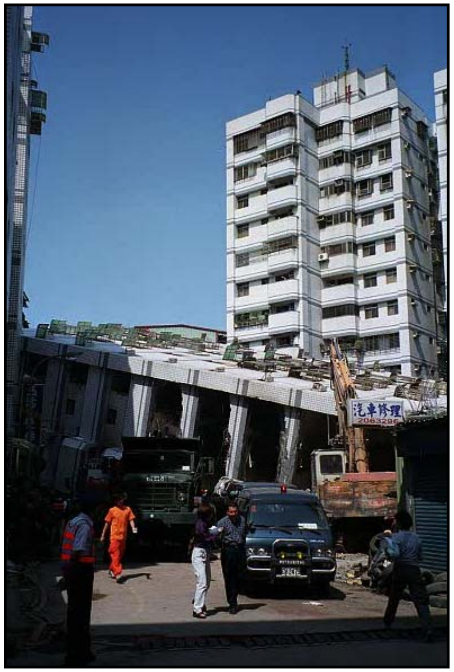
Model Estimates Contribution from Many, but Not All, Sources of Loss

- What elements are considered?
  - Direct sources of loss
    - Building
    - Contents
  - Indirect sources of loss
    - Loss of use/business interruption
    - Demand surge
  - Policy and reinsurance terms
- What is not included?
  - Additional sources of loss
    - Non-modeled perils
    - Contingent business interruption
  - Other contract expenses
    - Loss adjustment
    - Profits, commissions, fees, etc…

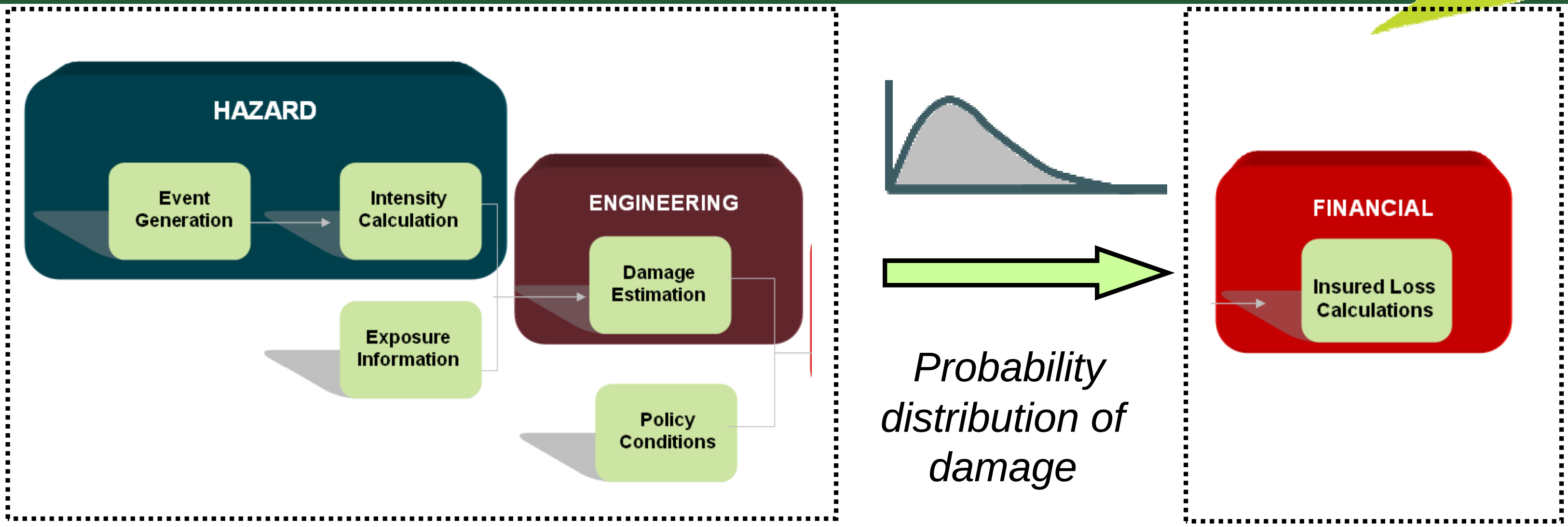
The Financial Model Must Account for Uncertainty in Modeled Damage Estimates

- When calculating damage, models must account for variability in damage, even for similar buildings subjected to the same intensity
- The variability can be attributed to differences in
  - Construction quality and practices
  - Local intensity
  - Unmodeled phenomena
- Claims analysis and damage surveys confirm this observation





The Peril Models Provide Estimates of the Probability of Damage, Not Just a Single Value



- Peril models calculate a probability distribution of damage for each location.
- The mean of the distribution is the mean damage ratio for the intensity of each event.
- Financial module uses the distributions when applying insurance and reinsurance terms
- Application of terms is independent of the peril model simulation

Insurance Terms Considered by Financial Module

Deductibles

- At location level
  - By site: $, %, % of loss
  - By coverage: $ and %
  - Combined (Building, Other Structures, Contents): $ and %
  - CEA Mini Policy: $ and %
  - Franchise
- At policy level
  - Attachment point
  - Minimum
  - Maximum
  - Minimum and maximum
  - % of loss
  - Franchise
  - Blanket

Limits

- At location level
  - Site
  - By coverage
- At policy level
  - Blanket
  - Excess
  - Sublimits
  - First loss
  - Reduced Indemnity

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Reinsurance Terms Considered by Financial Module

- Facultative reinsurance
  - Proportional
  - Non-proportional
  - Available at policy or individual locations
- Risk-based treaty reinsurance
  - Quota share
  - Surplus share
  - Per risk excess of loss
  - Includes special conditions
    - Line of business and region specific
    - Occurrence limits
    - Aggregate limits
- Portfolio (CAT) treaty reinsurance
  - Occurrence
  - Aggregate (stop loss)

Example Applications of the Financial Model

- With knowledge of the basic approach, extension to more complex situations is straightforward
  - Single location policies with multiple coverages
  - Multiple location policies
  - Reinsurance treaties
- Example calculations using the financial model
  - Single location policies
    - Deductible application spreadsheet
  - Multiple location policies
  - Reinsurance treaties
- Advanced topics with business applications
  - Back allocation
  - Multiple layer policies
  - Sublimits
  - Multiple region analyses

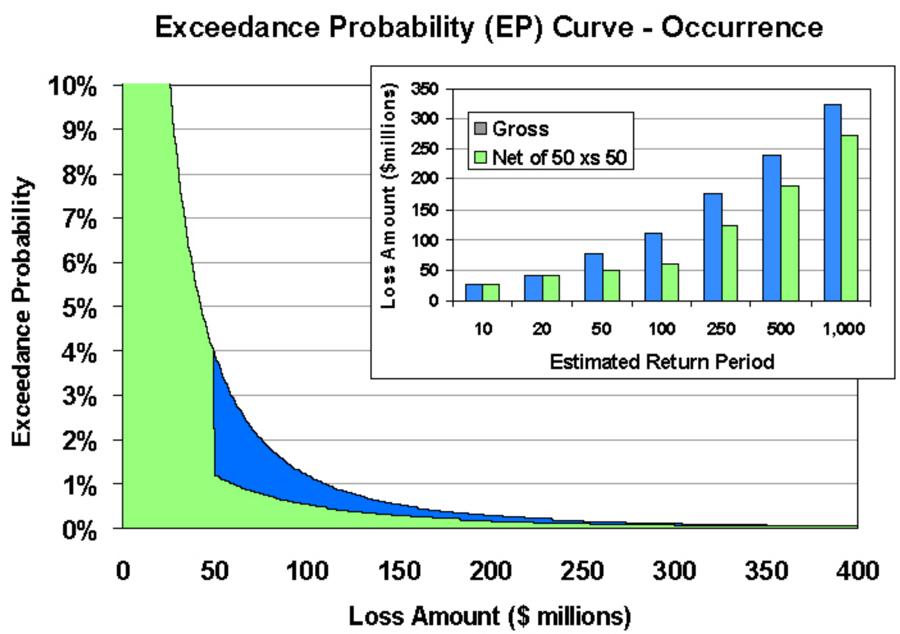
Summary on Financial Modeling

- The goal of the financial model is to compute the losses that result from the damage estimates produced by the peril models
- Accounting for uncertainty by modeling a realistic distribution around the mean damage ratio will result in a more accurate interpretation of the impact of policy conditions on losses
- The calculations within the financial model have a direct impact on the losses on which underwriting and portfolio decisions are based
- Catastrophe modelers should understand how modeling systems treat complex policy terms and conditions

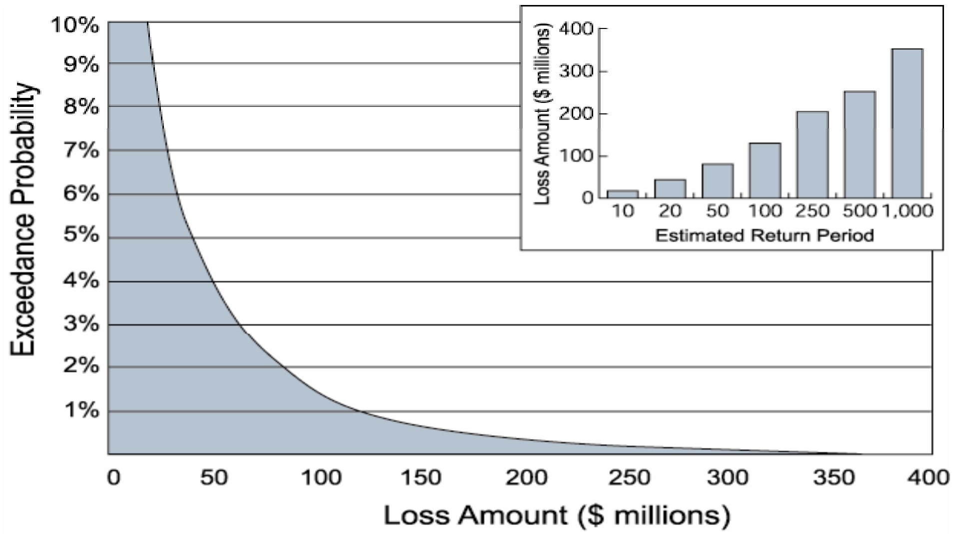
Interpreting Model Results

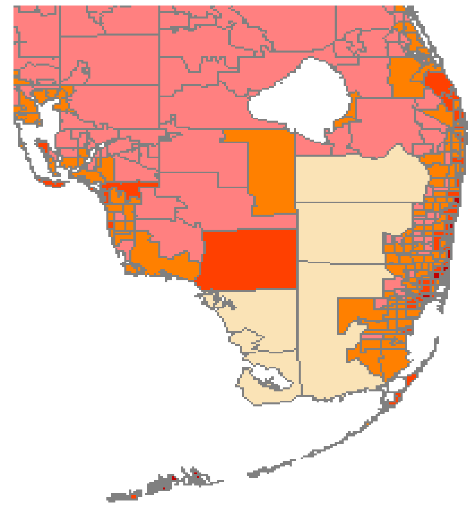
Results of the Catastrophe Models

- Event by event loss information
- Probability distribution of losses (EP curves)
- Annual aggregate losses
- Annual occurrence losses
- Industry and company specific losses
- Direct, ceded and net retained losses
- Large losses, PML's
- Loss costs
- Sorted output
  - geographic area, line of business, construction type



Catastrophe Models Provide a Wide Range of Outputs





Event	Year	Company Loss	Event Info
270011986	3657	2,811,789	Class 5 Hurr FL LA BF MS TX
270017822	5454	2,672,028	Class 5 Hurr NY NJ CT MA PA
110128230	4470	1,951,563	Mw 8.1 EQ New Madrid
270004221	1295	1,946,088	Class 5 Hurr FL BF SS SJ VQ
270019211	5872	1,786,625	Class 5 Hurr TX FL LA BF MS
270018458	5649	1,658,905	Class 4 Hurr NY CT NJ MA NH
270006717	2023	1,634,955	Class 4 Hurr FL BF SS SJ VQ
270010779	3294	1,625,767	Class 5 Hurr FL NC SC TN BF
110083756	2917	1,605,027	Mw 8.3 EQ San Francisco
270010551	3232	1,562,932	Class 5 Hurr FL AL JM MS LA
270022466	6869	1,562,240	Class 2 Hurr FL PQ DR GA BF
270016561	5063	1,475,085	Class 5 Hurr FL BF GA SC
110124693	4350	1,465,897	Mw 8.2 EQ San Francisco
270007716	2349	1,444,885	Class 5 Hurr FL MS JM AL LA
270021324	6512	1,397,606	Class 4 Hurr FL CJ JM BF TD

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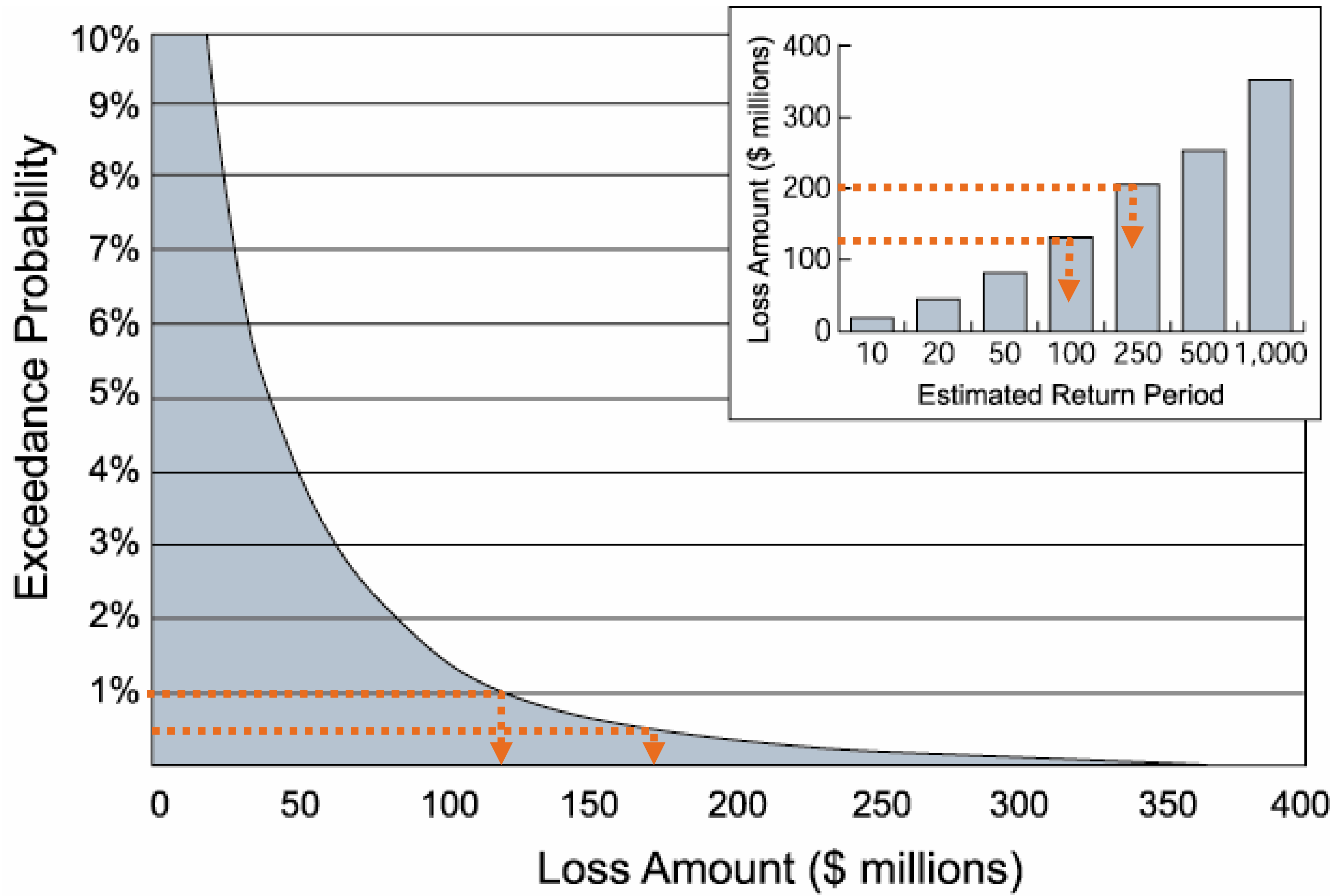
Standard Output is a Loss Exceedance Probability Curve



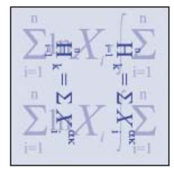
- **Consider Loss Output as Probabilities, Not Return Periods**

Analysis Assumptions

- An Assumptions report summarizing the data and assumptions is provided for review prior to simulation.
- Documents the modeled data for your review

Catastrophe Loss Analysis Service

Data Assumptions Document



Prepared for:
ABC Companyl

January 9, 2004

- Detailed summary of insurance terms
  - Application
  - Coverages
  - Limits
  - Deductibles
  - Replacements

Line of Business & Coverage Summary														
LOB Code	Limits Apply	A Building			B Other Structures			C Contents			D Loss of Use			
		Rep	Limit	Ded	Rep	Limit	Ded	Rep	Limit	Ded	Rep/d*	Limit	Ded
Condo	C	L	10% CovC	BA, BP	$0	$0	$0	L	$50,000	BA, BP	$150	40% CovC	BA, BP
Owners	C	L	$100,000	BA, BP	L	10% Cov A	BA, BP	L	50% CovA	BA, BP	$150	20% CovA	BA, BP

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Sample Exposure Summary

Exhibit I.a:FL

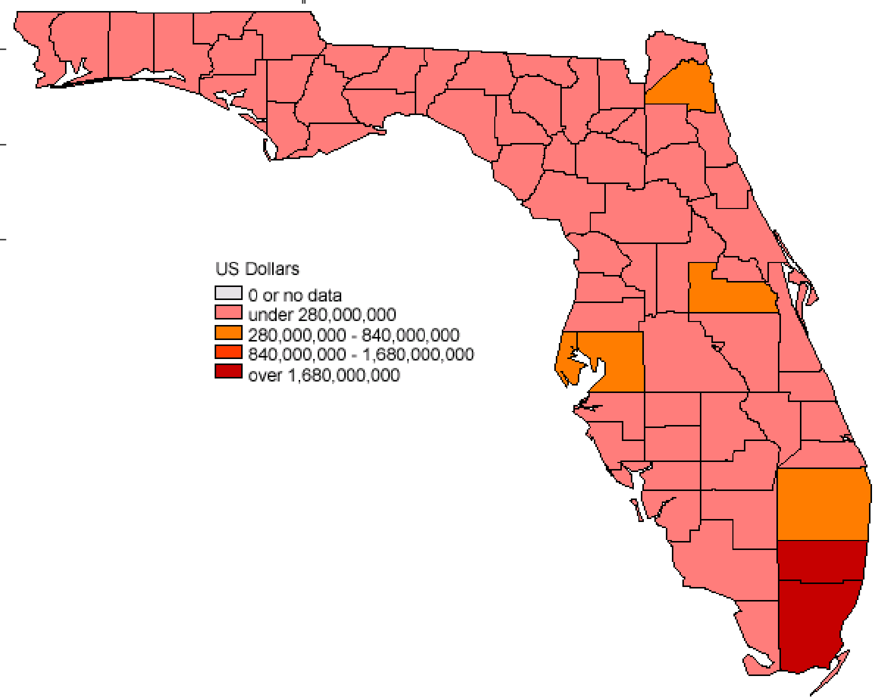
Insured Value Summary by County - All Coverages

Hurricane

Florida

Cancel	*HO*	*Total*
Alachua		
Value	100,131,288	100,131,288
Num. Risks	614	614
Avg. Value	163,080	163,080
Baker		
Value	3,534,710	3,534,710
Num. Risks	28	
Avg. Value	126,240	
Bay		
Value	126,969,155	
Num. Risks	1,180	
Avg. Value	107,601	
Bradford		
Value	11,840,948	
Num. Risks	96	
Avg. Value	123,343	
Brevard		
Value	146,186,858	

Detailed Reports
- **State**
- **County**
- **Zip**
- **Location**



Customized Maps
- **State**
- **County**
- **Zip**
- **Location**

Sample Output: Average Annual Losses

Exhibit III.a:FL

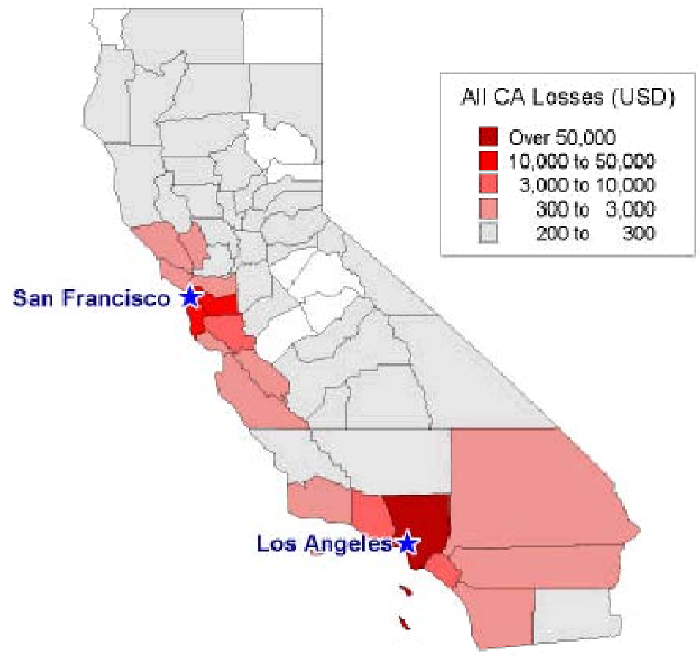
Distribution of Exposures and Losses by County

Hurricane

Florida

County	*Insurance in Force**	*Expo.(%)*	*Est. Avg. Annual Loss**	*Loss(%)*
Dade	2,685,425,029	26.70	8,176,098	49.60
Broward	1,683,535,079	16.70	3,248,721	19.70
Palm Beach	612,604,722	6.10	1,258,249	7.60
Pinellas	779,617,497	7.70	868,774	5.30
Hillsborough	809,851,549	8.00	485,428	2.90
Sarasota	181,439,454	1.80	203,523	
Collier	116,989,287	1.20	203,370	
Pasco	203,302,975	2.00	192,977	
Orange	356,193,480	3.50	156,457	
Brevard	146,186,858	1.50	154,887	
Lee	102,194,284	1.00	144,169	
Duval	355,270,434	3.50	139,691	
Manatee	98,567,621	1.00	134,367	
Bay	126,969,155	1.30	109,080	
Volusia	113,239,216	1.10	62,440	
Polk	126,172,334	1.30	62,307	
Marion	138,087,873	1.40	61,343	
Charlotte	43,945,123	0.40	58,817	
Seminole	119,271,988	1.20	55,348	
Okaloosa	91,222,609	0.90	53,221	
St. Johns	73,698,466	0.70	51,106	
Escambia	85,230,548	0.80	50,422	
St. Lucie	35,486,130	0.40	47,921	
Hernando	62,606,162	0.60	43,531	
Martin	19,220,895	0.20	42,768	
Leon	164,125,274	1.60	41,618	
Citrus	83,114,000	0.80	41,053	
Lake	100,590,841	1.00	40,897	
Alachua	100,131,288	1.00	34,964	

Detailed Reports
- **State**
- **County**
- **Zip**
- **Location**



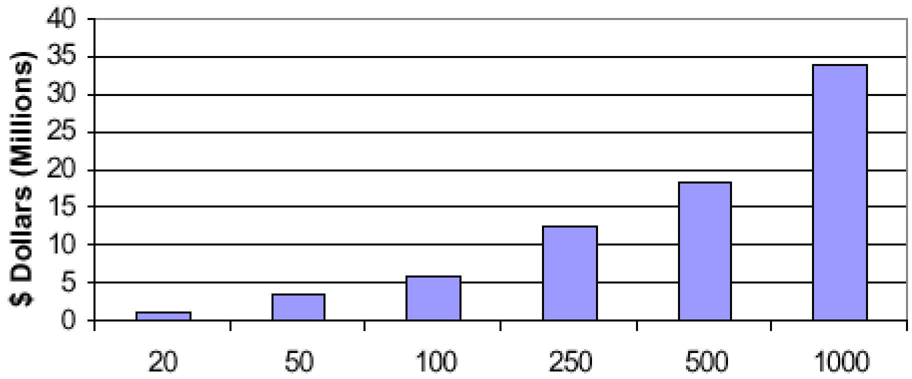
Customized Maps

Sample Output: Probability Distributions

Exhibit 1: Annual Occurrence Loss

Estimated Average Return Time (years)	Estimated Probability of Exceedance	Earthquake Occurrence ($millions)
20	0.050	1.2
50	0.020	3.6
100	0.010	6.0
250	0.004	12.3
500	0.002	18.2
1,000	0.001	33.9

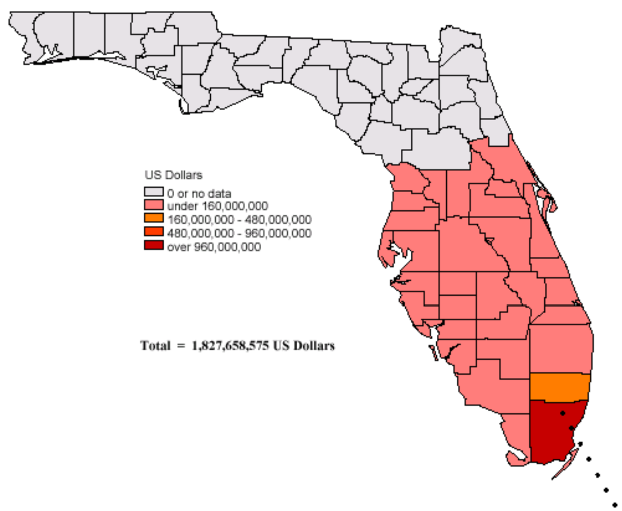
Exhibit 2: Estimated Occurrence Loss Distribution



Sample Output: Mean Losses for Specific Events

The Largest Loss by County

Magnitude Saffir Simpson 5 Hurricane making landfall at -80.2225°, 25.4162°(Total)



Loss Report for Cat 5 Hurricane

Available For All Perils

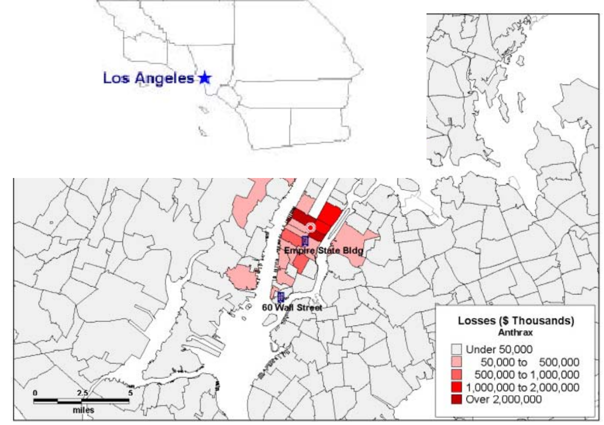


Exhibit V.a: US (cont.)

State	*County*	*HO*	*Total*
FL	Seminole	6,507	6,507
FL	St. Lucie	110,387	110,387
FL	Sumter	1,300	1,300
FL	Volusia	29	29
Total		**1,827,658,575**	**1,827,658,575**

* US Dollars

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Return Periods are Frequently Misinterpreted

"Katrina is a 1 in 25 year hurricane loss for the U.S."

2005

2030

"There is a 4% annual probability that a Katrina-sized hurricane loss could occur in the U.S."

2009
4% Probability

2010
4% Probability

. . .

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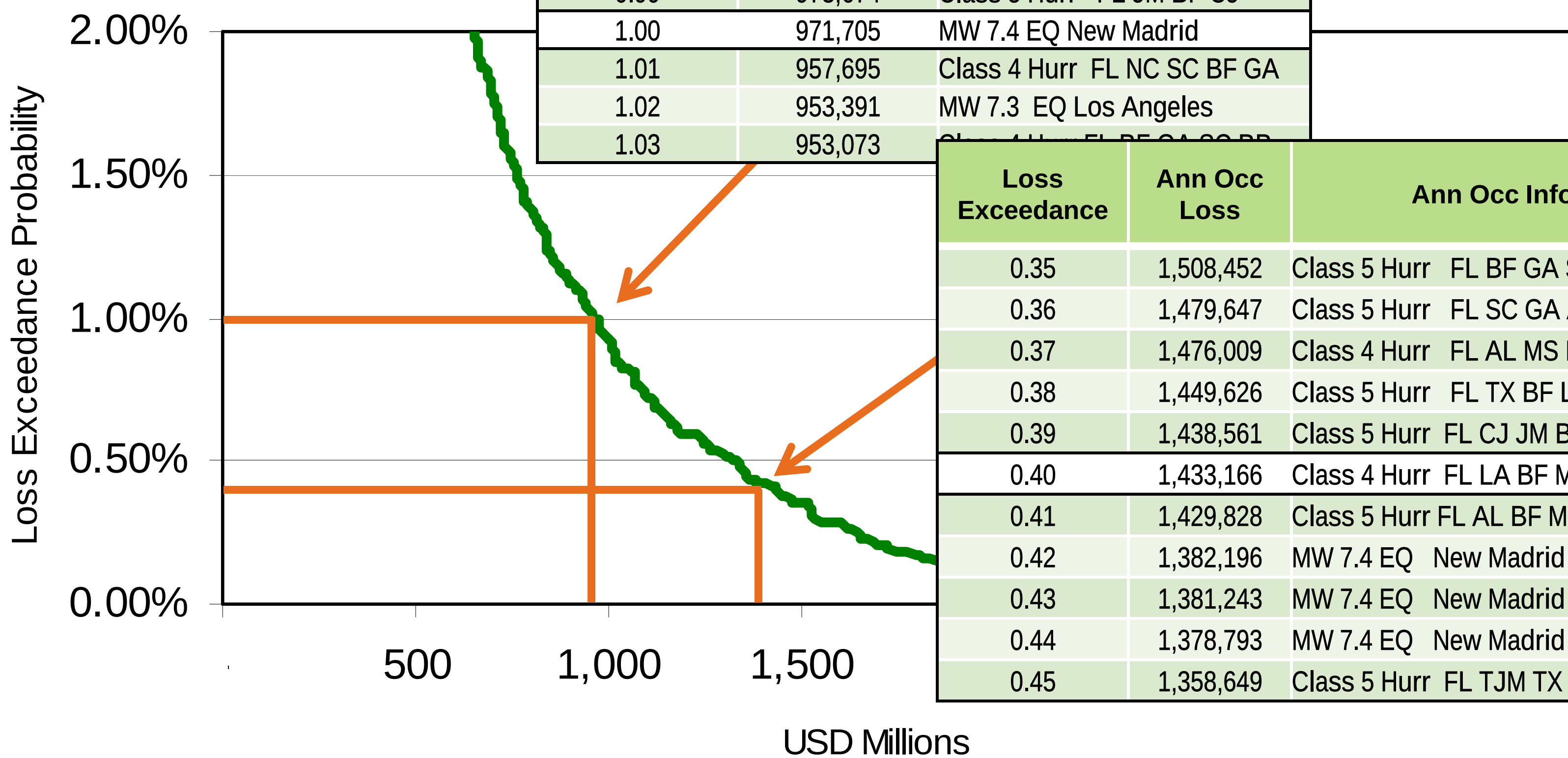
Long Return Periods Incorrectly Imply Losses Will Not Occur "In My Lifetime"

- PML means different things to different people
  - "It's the worse case scenario"
  - "Something that will never happen"
  - "The one in one hundred event"
  - "Whatever A.M.Best asks us for"
- PML is ingrained in insurance industry thinking
  - A holdover from pre-model days
- Models provide a full distribution of risk potential with associated probabilities
- A 100-year return period means that there is a 1% annual probability of that size loss or larger

Models Provide Probabilities of Loss, Not Probabilities of Events



Loss Exceedance%	Ann Occ Loss	Ann Occ Info
0.97	977,066	Class 5 Hurr FL TX LA PQ BF
0.98	974,039	Class 4 Hurr SC NC FL CJ GA
0.99	973,674	Class 5 Hurr FL JM BF CJ
1.00	971,705	MW 7.4 EQ New Madrid
1.01	957,695	Class 4 Hurr FL NC SC BF GA
1.02	953,391	MW 7.3 EQ Los Angeles
1.03	953,073	Class 4 Hurr FL BF GA SC BB

Loss Exceedance	Ann Occ Loss	Ann Occ Info
0.35	1,508,452	Class 5 Hurr FL BF GA SC
0.36	1,479,647	Class 5 Hurr FL SC GA AL BF
0.37	1,476,009	Class 4 Hurr FL AL MS BF LA
0.38	1,449,626	Class 5 Hurr FL TX BF LA SS
0.39	1,438,561	Class 5 Hurr FL CJ JM BF TD
0.40	1,433,166	Class 4 Hurr FL LA BF MS SS
0.41	1,429,828	Class 5 Hurr FL AL BF MS GA
0.42	1,382,196	MW 7.4 EQ New Madrid
0.43	1,381,243	MW 7.4 EQ New Madrid
0.44	1,378,793	MW 7.4 EQ New Madrid
0.45	1,358,649	Class 5 Hurr FL TJM TX BF LA

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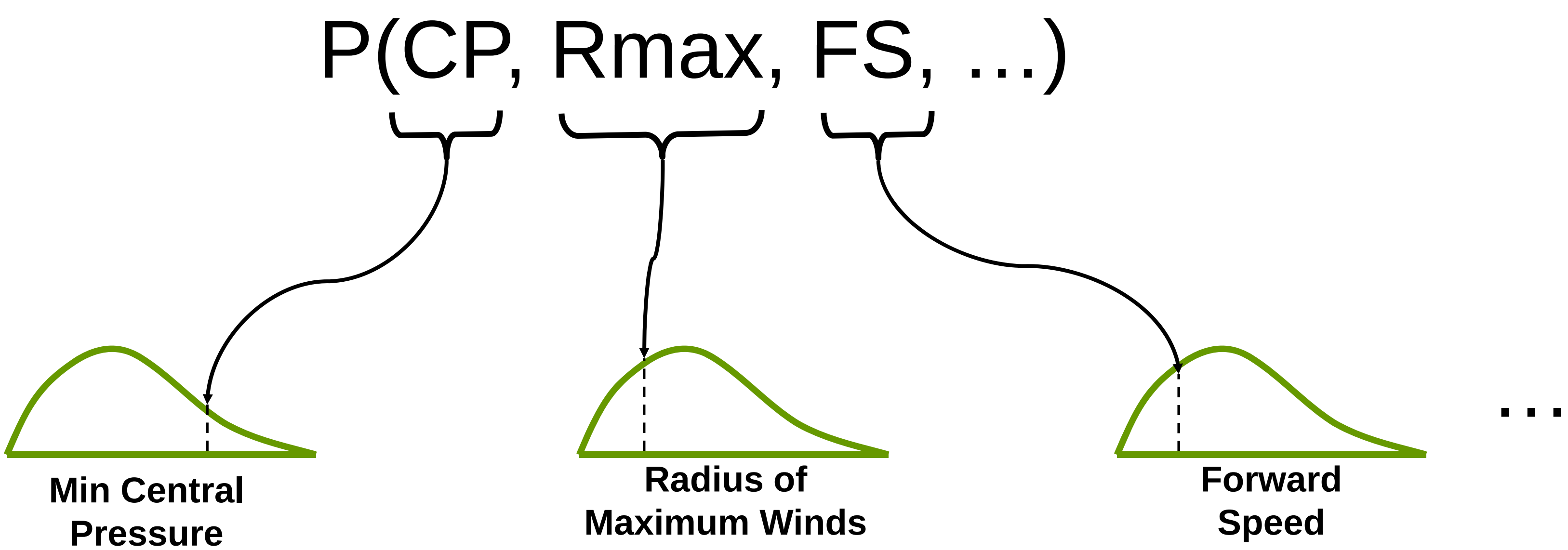
What is the Probability of a Specific Event?



P(Single Event) **= 1 / ∞ = 0**

Models Can Provide the Probability of Different Types of Events

Event ID	Year	State	County	SS Scale	Longitude	Latitude	Central Pressure	Max Windspeed	Industry Loss
270012931	3888	LA	Plaquemines	3	-89.17	29.37	962.8	109.1	2,379,385,213
270002073	638	TX	Galveston	4	-94.39	29.49	943.8	126.4	1,169,523,187
270004331	1304	MS	Jackson	3	-88.42	30.27	958.7	116.2	2,425,661,519
270000660	200	LA	Iberia	3	-91.68	29.49	957.7	114.7	1,467,115,619
270012025	3617	LA	Lafourche	5	-90.5	29.16	897.7	165.8	32,179,256,355
270000349	103	LA	Iberia	4	-92.07	29.58	934	133.7	4,550,417,528
270023237	7015	TX	Brazoria	3	-95.18	29.05	951.2	121.7	6,552,011,909
270011455	3438	MS	Jackson	3	-88.52	30.22	956	113.6	4,130,229,662
270014646	4414	LA	Plaquemines	4	-89.07	29.87	931.3	135.3	27,758,529,327
270000935	277	TX	Brazoria	4	-95.61	28.78	942.8	126.3	6,029,080,432
270029991	9057	AL	Baldwin	3	-87.59	30.34	955.6	115.8	1,580,530,915
270020334	6128	AL	Baldwin	4	-87.74	30.34	930.9	140.9	4,993,300,124
270012769	3842	MS	Jackson	5	-88.5	30.23	911.3	158.7	16,793,312,346
270018283	5529	MS						164.5	56,942,806,766
270019373	5853	AL						107.3	1,004,149,493
270000363	108	LA						150.9	11,024,114,242
⋮	⋮	⋮						⋮	⋮

	Gulf Hurricane
P (Cat 3) = 3,303/10,000	33.0%
P (Cat 4) = 1,488/10,000	14.9%
P (Cat 5) = 231/10,000	2.3%

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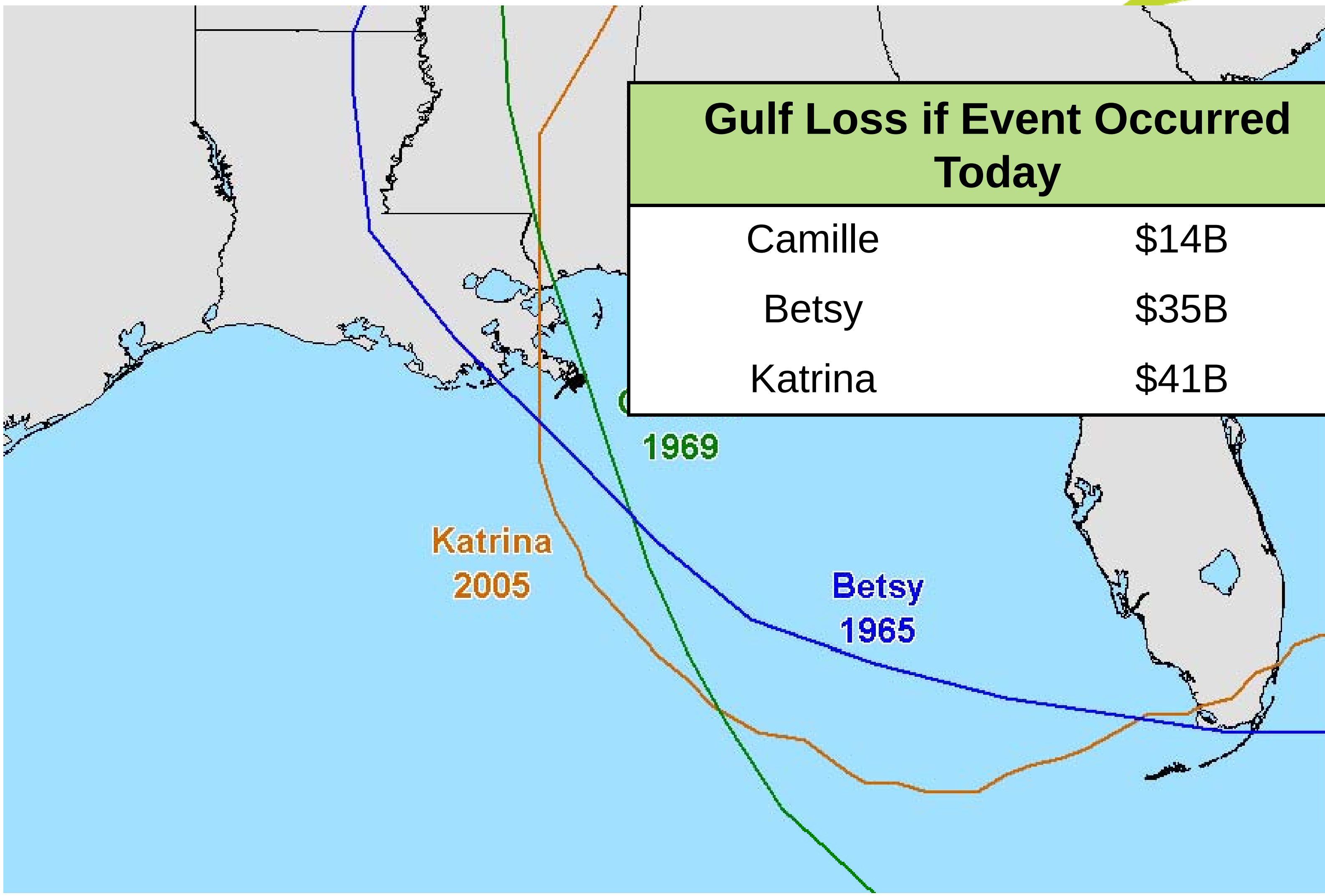
No Historical Event Will Ever Occur Again



Gulf Loss if Event Occurred Today	
Camille	$14B
Betsy	$35B
Katrina	$41B

Models Provide the Probability of Losses, Not the Probability of an Event

Exceedance Probability	Annual Occurrence Loss	Annual Aggregate Loss
•	•	•
•	•	•
•	•	•
0.15	53,738,239,362	56,110,982,780
0.16	50,270,776,997	55,341,168,718
0.17	49,913,421,931	53,738,239,362
0.18	49,859,663,629	52,080,041,127
0.19	49,819,414,592	51,707,961,972
0.20	49,561,956,519	50,768,968,601
0.21	48,500,900,897	50,054,523,376
0.22	48,292,060,441	49,977,120,866
0.23	48,106,958,762	49,859,663,629
0.24	47,431,290,406	49,819,414,592
0.25	45,416,129,581	
0.26	45,285,783,212	
0.27	44,790,150,796	
0.28	43,834,515,306	
0.29	42,337,563,871	
0.30	42,149,956,525	
0.31	40,765,613,551	
0.32	40,132,315,421	
0.33	39,586,673,793	
•	•	
•	•	
•	•	

	Gulf Hurricane
P_{Loss} > Camille	3.3%
P_{Loss} > Betsy	0.4%
P_{Loss} > Katrina	0.3%

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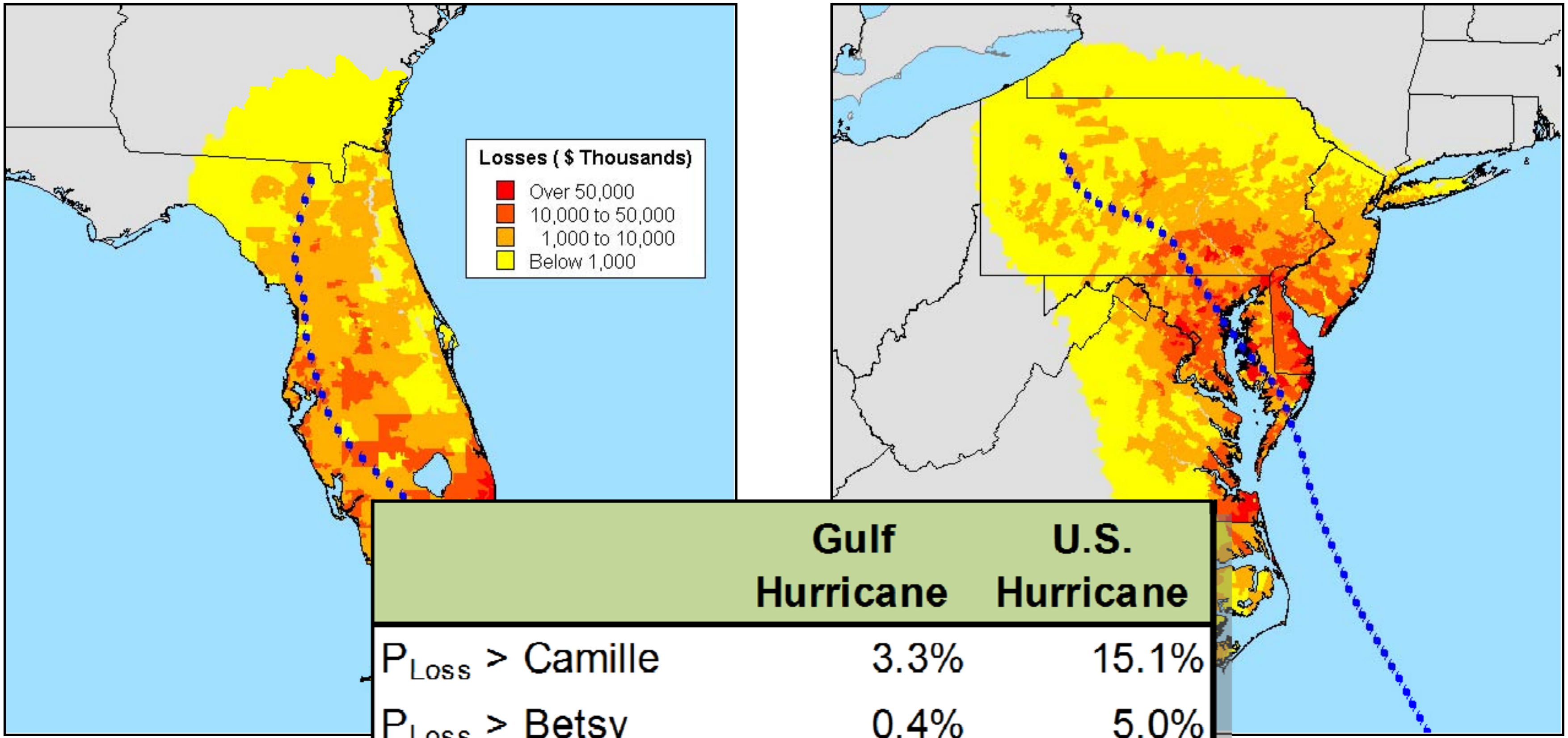
Many U.S. Hurricane Scenarios Could Cause Losses Equal to or Greater than Katrina



	Gulf Hurricane	U.S. Hurricane
P_{Loss} > Camille	3.3%	15.1%
P_{Loss} > Betsy	0.4%	5.0%
P_{Loss} > Katrina	0.3%	4.1%

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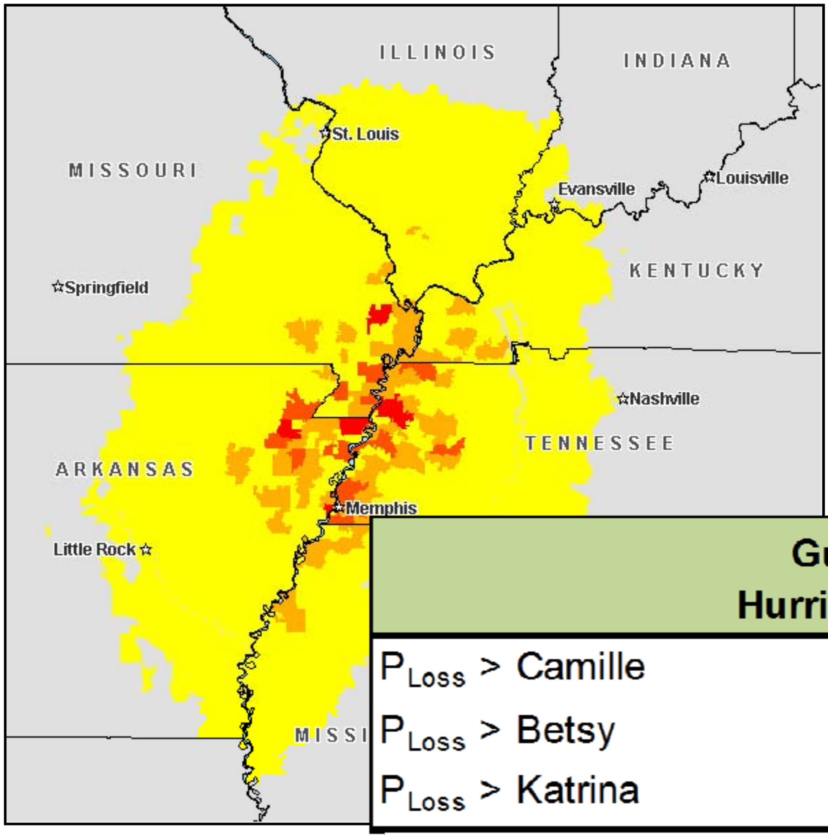
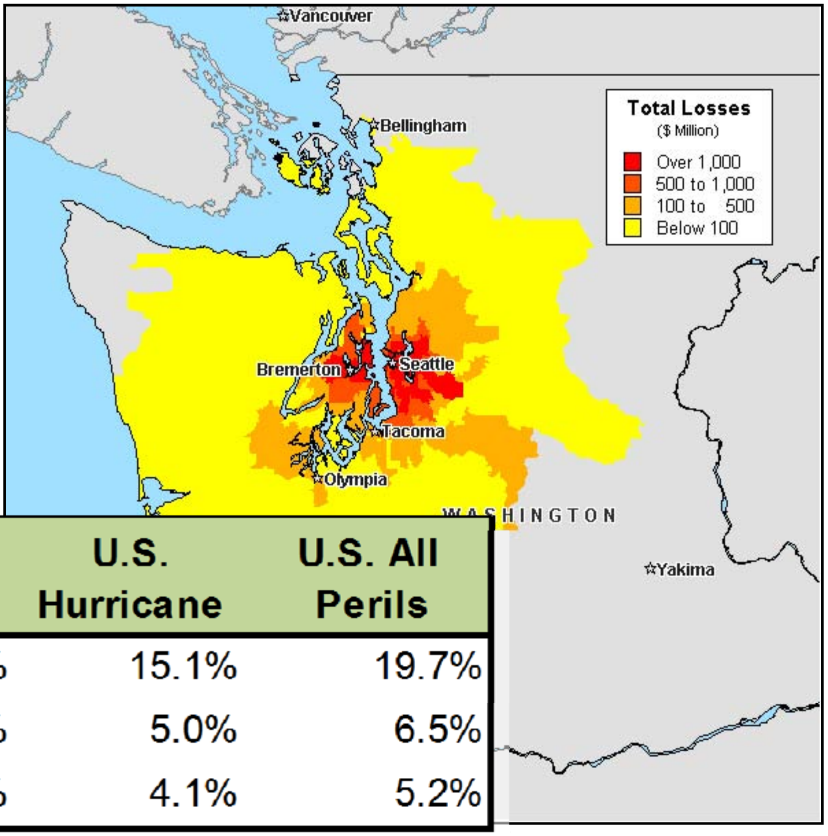
Loss Probabilities Increase When Considering All Perils

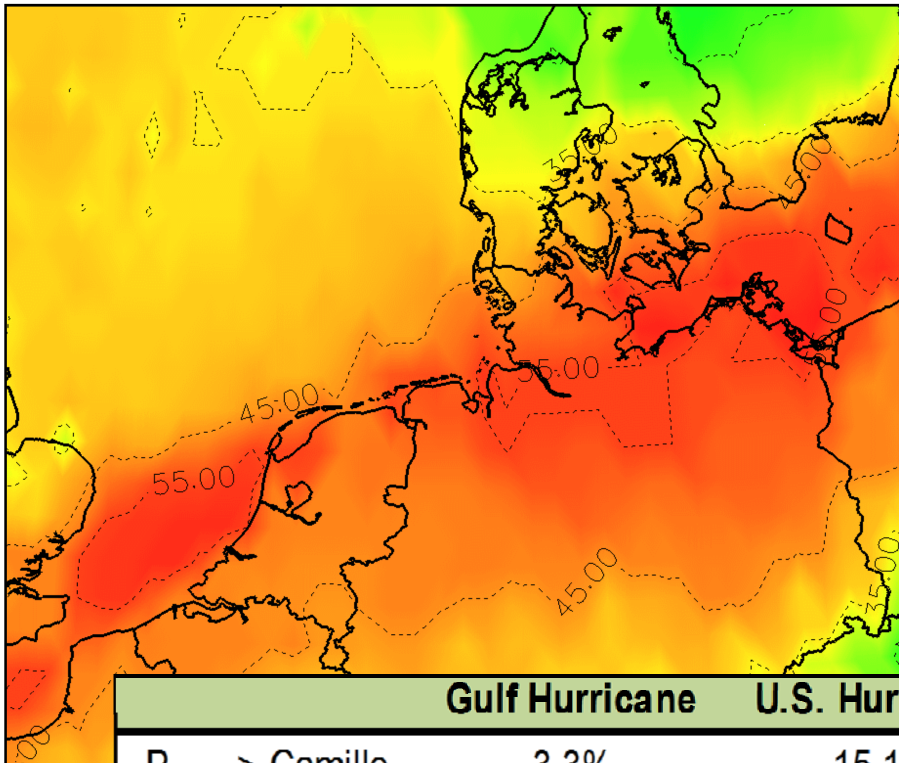




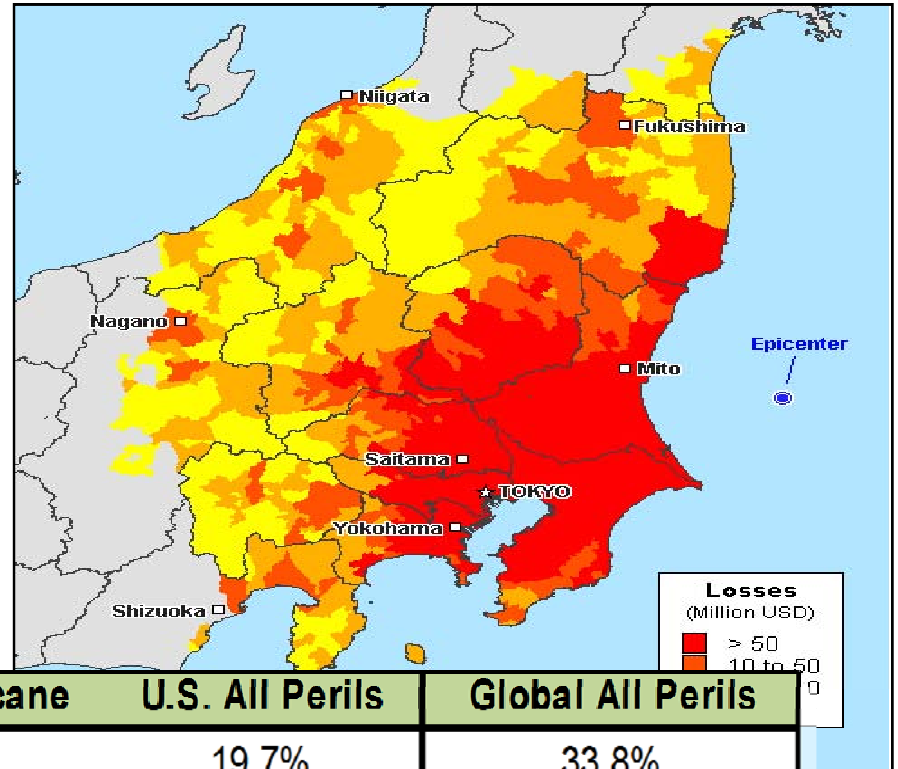
	Gulf Hurricane	U.S. Hurricane	U.S. All Perils
P_{Loss} > Camille	3.3%	15.1%	19.7%
P_{Loss} > Betsy	0.4%	5.0%	6.5%
P_{Loss} > Katrina	0.3%	4.1%	5.2%

Loss Probabilities Increase When Considering Global Portfolios

European Windstorm



Japan Earthquake - 8.0 Magnitude



	Gulf Hurricane	U.S. Hurricane	U.S. All Perils	Global All Perils
P_{Loss} > Camille	3.3%	15.1%	19.7%	33.8%
P_{Loss} > Betsy	0.4%	5.0%	6.5%	11.1%
P_{Loss} > Katrina	0.3%	4.1%	5.2%	8.8%

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Evaluating Portfolio Risk Based on Regional Losses Can Underestimate Actual Risk

	EV	5%	2%	1%	0.40%	0.20%	0.10%
Florida	88,532	430,820	960,702	1,583,573	2,456,240	3,493,607	4,461,022

	EV	5%	2%	1%	0.40%	0.20%	0.10%
Gulf	50,963	278,431	507,331	681,241	1,040,441	1,246,136	1,712,889

	EV	5%	2%	1%	0.40%	0.20%	0.10%
Southeast	14,627	69,491	187,918	317,683	454,516	555,225	665,121

	EV	5%	2%	1%	0.40%	0.20%	0.10%
East Coast	31,789	89,841	302,462	607,099	1,272,425	2,353,480	3,528,153

	EV	5%	2%	1%	0.40%	0.20%	0.10%
U.S.	172,321	724,209	1,340,950	2,064,604	3,432,493	4,488,137	5,693,138

Evaluating Portfolio Risk Based on Single Country Losses Can Underestimate Actual Risk

	EV	5%	2%	1%	0.40%	0.20%	0.10%
France	190,164	1,041,163	1,827,144	2,329,030	3,125,430	3,664,796	4,315,150

	EV	5%	2%	1%	0.40%	0.20%	0.10%
Germany	48,877	226,736	612,047	969,368	1,748,242	2,535,825	2,998,433

	EV	5%	2%	1%	0.40%	0.20%	0.10%
United Kingdom	64,364	320,213	675,240	1,001,590	1,898,679	2,267,980	2,843,990

	EV	5%	2%	1%	0.40%	0.20%	0.10%
Europe	303,406	1,541,731	2,456,897	3,201,013	4,365,344	5,365,344	6,377,127

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Using Single Peril Analyses Will Lead to an Underestimation of Catastrophe Risk

	EV	5%	2%	1%	0.40%	0.20%	0.10%
Hurricane	78,508,811	339,071,187	503,429,518	693,817,715	959,262,565	1,092,055,628	1,303,179,422

	EV	5%	2%	1%	0.40%	0.20%	0.10%
Earthquake	27,120,338	158,879,967	264,089,927	405,934,077	742,971,254	983,646,511	1,141,000,940

	EV	5%	2%	1%	0.40%	0.20%	0.10%
Severe Thunderstorm	60,308,841	196,058,211	312,291,274	504,203,661	715,506,615	960,019,277	1,166,591,807

	EV	5%	2%	1%	0.40%	0.20%	0.10%
Combined Perils	129,915,455	430,705,438	655,847,183	866,008,366	1,116,176,497	1,318,694,700	1,685,204,827

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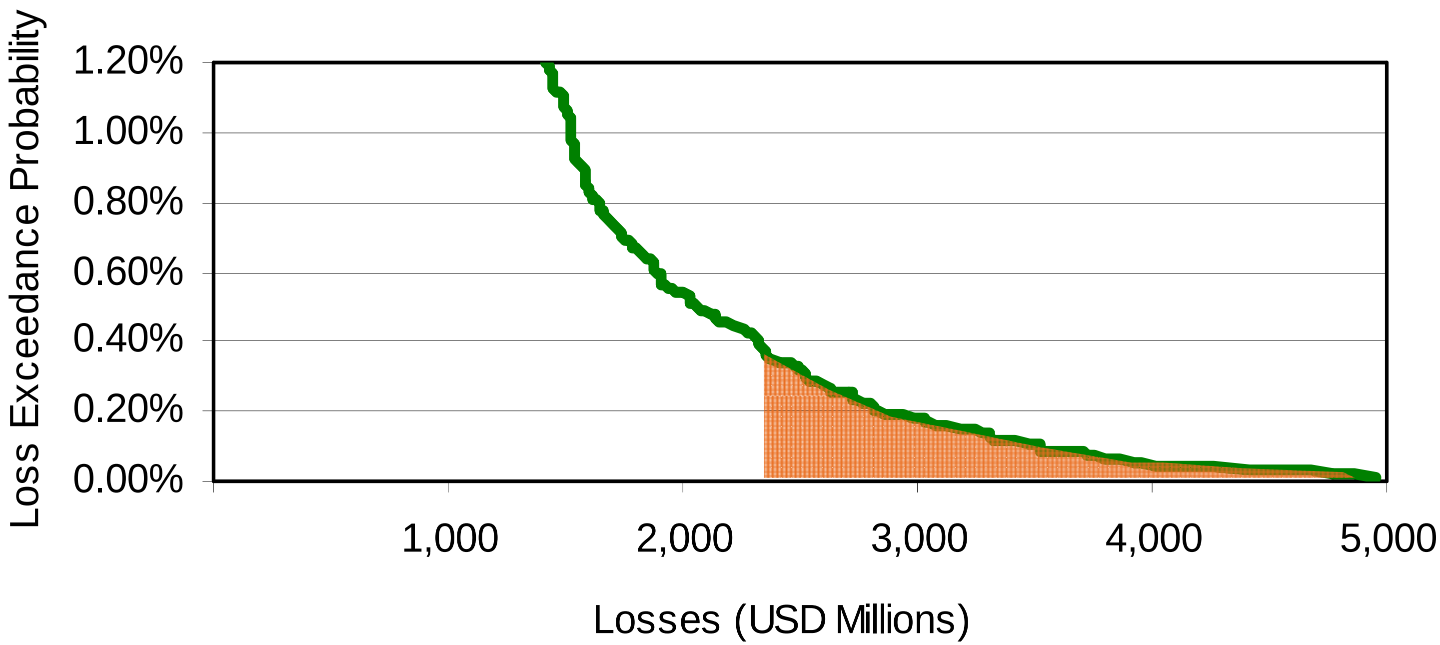
Assessing Risk Beyond 0.4% Exceedance Probability

- Tail Value-At-Risk (TVAR): Average of all simulated event losses beyond specified probability, such as 1% or 0.4%



TVAR is Easily Calculated Using Model Output

Loss Exceedance Probability	Aggregate Loss
.	.
.	.
.	.
0.40	311,100,395
0.39	312,027,252
0.38	315,590,675
0.37	315,925,077
0.36	316,539,935
0.35	321,534,834
.	.
.	.
.	.
0.06	403,624,382
0.05	422,855,644
0.04	429,665,083
0.03	516,419,526
0.02	532,142,180
0.01	852,654,660

$TVAR_{0.4}$ = Prob wtd average of losses beyond 0.4% probability

= $387 Million

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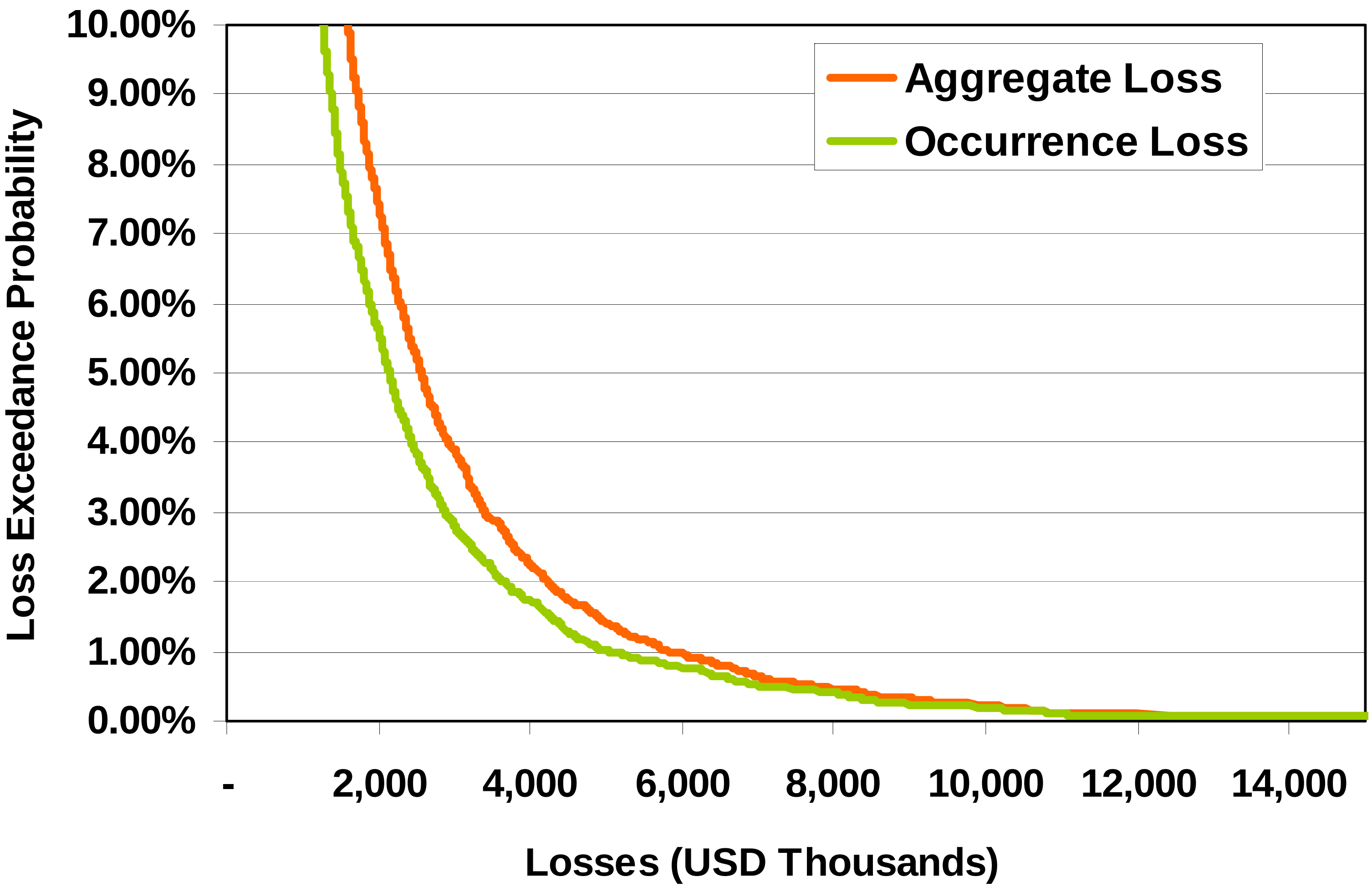
Manage Portfolio Risk Using Aggregate and Occurrence Loss Information



Understanding Large Aggregate Loss Years Helps Evaluate Alternative Reinsurance Options

Year 5063 $1.227B	
$942M	Florida Hurricane
$125M	Texas Severe Thunderstorm
$33M	Midwest Severe Thunderstorm
$30M	Gulf Severe Thunderstorm
$12M	Texas Severe Thunderstorm
$11M	Plains Severe Thunderstorm
$10M	Texas Severe Thunderstorm
$10M	Upper Midwest Severe Thunderstorm

$100M + in Aggregate Severe Thunderstorm Losses

Year 6753 $1.226B	
$400M	Florida Hurricane
$363M	Texas Severe Thunderstorm
$332M	**Florida Hurricane**
$23M	Midwest Severe Thunderstorm
$12M	Midatlantic Severe Thunderstorm

Year 2521 $1.222B	
$638M	California Earthquake
$311M	California Earthquake
$132M	**Texas Severe Thunderstorm**
$19M	Gulf Hurricane
$19M	Southeast Severe Thunderstorm
$18M	Midwest Severe Thunderstorm
$15M	Southeast Severe Thunderstorm

Large 3rd Event Loss

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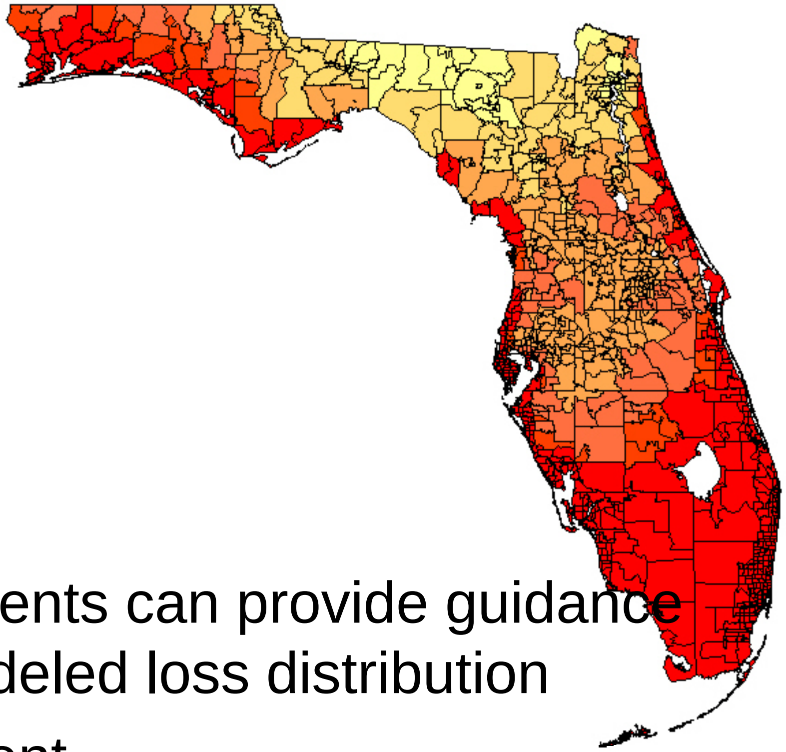
I’ve Run the Model, Have I Accounted for All the Risk?

- If you’ve got your exposure right then your loss distribution provides a robust starting point for catastrophe risk management
- Confirm loss results include all covered, modelable perils
- Do modeled losses include:
  - Loss adjustment expenses
  - Inland flooding
  - Hazardous waste cleanup
  - …
- Review of experience from past events can provide guidance for factors to be used to adjust modeled loss distribution
- Dependent on unique nature of event



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Best Practice Checklist for Interpreting Model Probabilities

- ☑ Evaluate model results as probabilities, not return periods
- ☑ Interpret model output as loss probabilities not event probabilities
- ☑ Evaluate risk using countrywide losses rather than regional losses
- ☑ Evaluate risk using all peril losses not single largest peril losses
- ☑ Analyze and manage losses beyond the 0.4% exceedance probability
- ☑ Manage to aggregate exceedance probability curve
- ☑ Confirm loss results correctly include all covered, modelable perils
- ☑ Benchmark company loss distributions against the industry loss distribution

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