Catastrophe Model Blending

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Agenda

- Why blend models
- Basic blending methods
- Selecting weight and model validation
- Blending beyond basics
- Summary

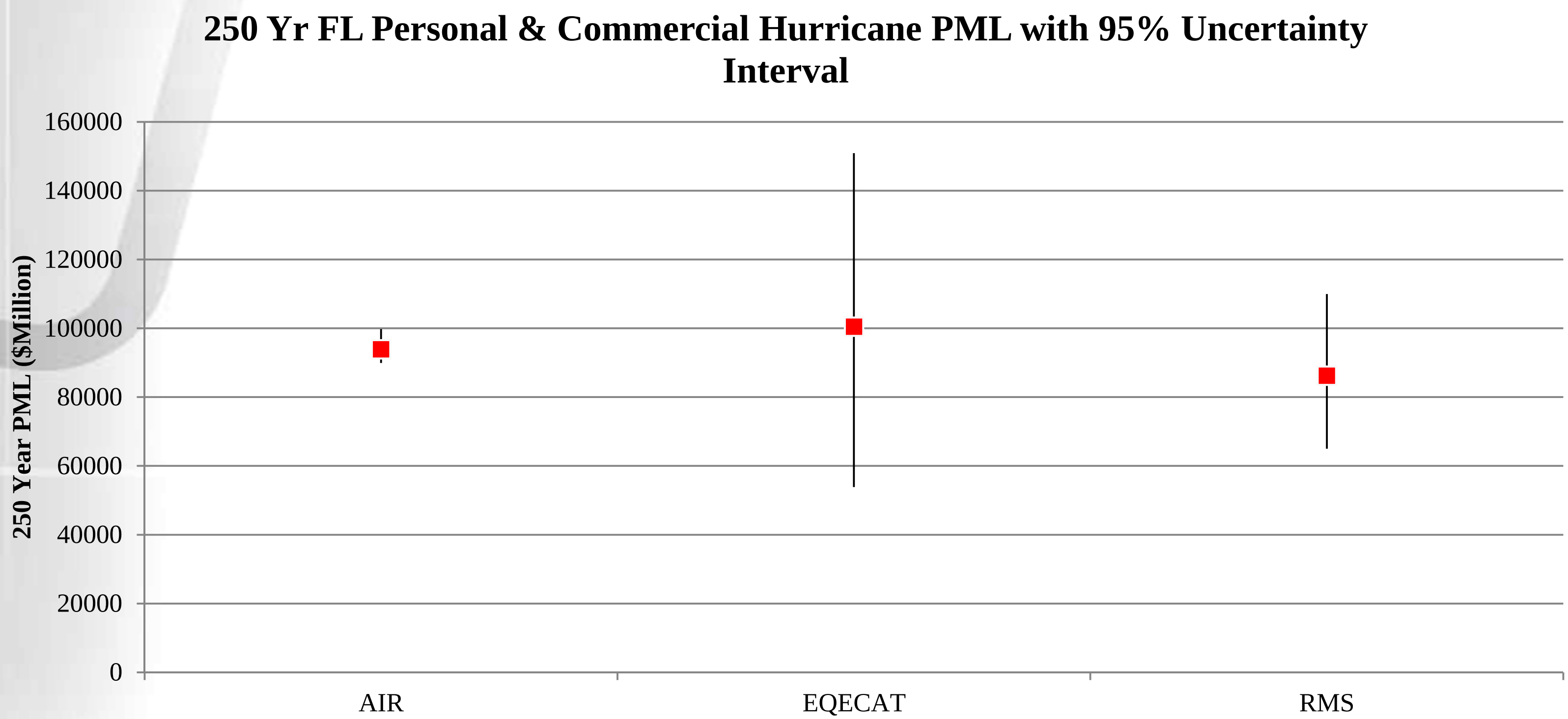
Why Blend Models

- Significant impact of cat models since 1990s.
  - Used in primary rate making (hurricane, earthquake ratings, reinsurance cost allocation, Net Cost of Reinsurance, Risk Provision, Catastrophe Tier Relativities, etc.)
  - Used in Reinsurance to calculate expected losses for pricing contracts
  - Used to calculated overall level of accumulation of risks for multiple perils for both insurers and reinsurers
  - Used for rating agency reporting, capital management, underwriting, Enterprise Risk Management, etc.

Why Blend Models

- Significant degree of uncertainties associated with the models
  - Large range of outputs
  - Poor perception of accuracy
  - Science is still evolving, big changes from year to year

Why Blend Models



Based on 2007 FHCF exposure data
Source: FCHLPM, 2011 Standard

FL PML	High	Low	Mean
AIR	99,778	89,933	93,902
EQECAT	150,910	53,863	100,496
RMS	109,974	64,977	86,255

Why Blending Models

- Allow companies to include multiple views, reduce the model risk that results from relying on a single vendor model's opinion.
  - Complexity of the models, numerous assumptions and judgments involved in model development
  - Lack of historical records to judge which model is the best
  - Big changes are not necessarily bad
- Smooth out the large changes of individual model, mitigate the output uncertainties

Rating Agency Views on Model Blending

- S&P: In the wake of widespread disaster-related losses for insurers and reinsurers, ratings firm S&P has reiterated its call for the use of multiple catastrophe models. In a press release, S&P said it preferred use of models from at least two of the big three modelling firms when assessing the catastrophe risk for natural peril catastrophe bonds. S&P says its criteria still allows the use of a single model when assessing catastrophe risk, but contends that using multiple models would increase transparency in the market and lower the risk of "model shopping" where risk managers purposely select the model that gives them the most desirable results.
- AM Best: When companies provide output from multiple catastrophe models, A.M. Best's baseline approach is to take the straight average. This, however, can be adjusted to a weighted average in cases where more refined information is available that supports greater reliance being placed on a given model. In either case, A.M. Best expects a company's management to be able to explain why it has utilized the output selected to best represent its catastrophe exposure.

Blending Methods

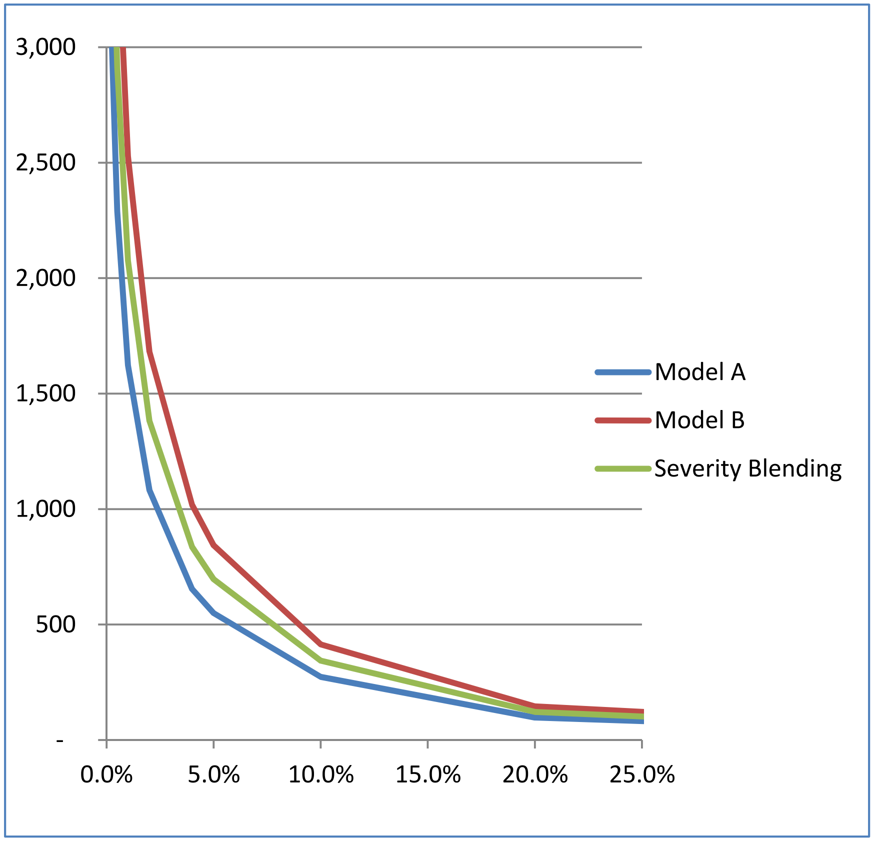
- Two major model outputs: AAL, PML/Tvar
- Different blending methods for different output
- Major blending methods:
  - Severity Blending (PML, TVar)
  - Frequency Blending (PML, AAL, TVar)
  - Simple or Weighted Average of Pure Premium (AAL) is consistent with both Frequency and Severity Blending
- Most of the time, the results from different blending methods won't be the same

Severity Blending

- Model A gives $3 Billion for the 100 Year PML, Model B gives $4 Billion for the same return period loss, then the 50-50 severity blend for the 100 year PML is $3.5 Billion.
- Advantages: Simple, different blending weight can be easily implemented
- Disadvantages:
  - Break the coherent and correlations of cat model events
  - Subsequent simulations (reinsurance pricing, annual aggregation, etc.) relying on the rank order of the events are impossible

Severity Blending

Exceedance Prob	Model A	Model B	Severity Blending
0.1%	3,952	6,345	5,149
0.2%	3,161	5,054	4,107
0.4%	2,559	3,890	3,224
0.5%	2,290	3,537	2,914
1.0%	1,623	2,529	2,076
2.0%	1,083	1,683	1,383
4.0%	653	1,018	836
5.0%	550	844	697
10.0%	273	414	344
20.0%	97	146	122
50.0%	5	3	4



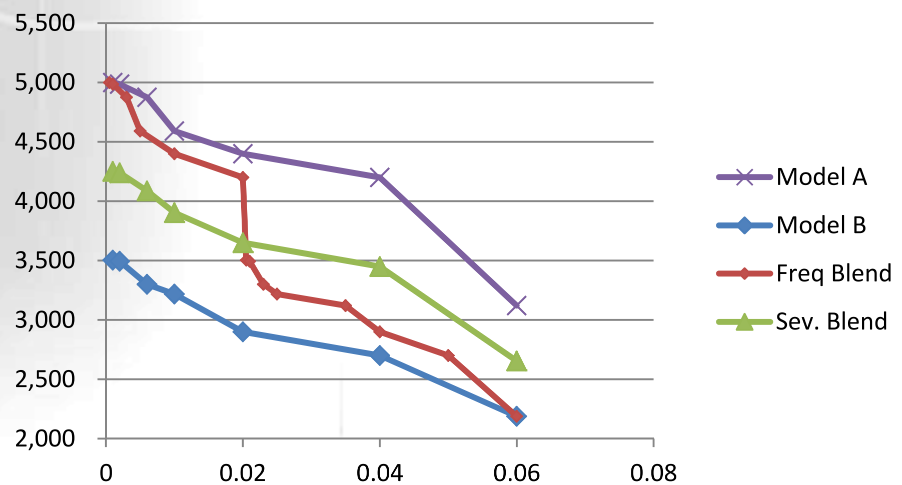
Frequency Blending

- Frequency is adjusted through simulations
- Sampling years from different models
  - Method 1: Sample from each of model A and B for certain percentage of years
  - Method 2: for each simulation year, sample from each model based on weight
- Broadly used for reinsurance, and risk management purposes.
- Requires the event loss table with probabilities associated with each event.

Frequency Blending

Before Blending

	Model A	Model A Prob.	Model B	Model B Prob
Event 1	5,000	0.001	3,504	0.001
Event 2	4,986	0.001	3,494	0.001
Event 3	4,875	0.004	3,300	0.004
Event 4	4,591	0.004	3,218	0.004
Event 5	4,400	0.01	2,900	0.01
Event 6	4,200	0.02	2,700	0.02
Event 7	3,121	0.02	2,189	0.02



After Blending

Event Loss	Prob
5,000	0.0005
4,986	0.0005
4,875	0.002
4,591	0.002
4,400	0.005
4,200	0.01
3,504	0.0005
3,494	0.0005
3,300	0.002
3,218	0.002
3,121	0.01
2,900	0.005
2,700	0.01
2,189	0.01

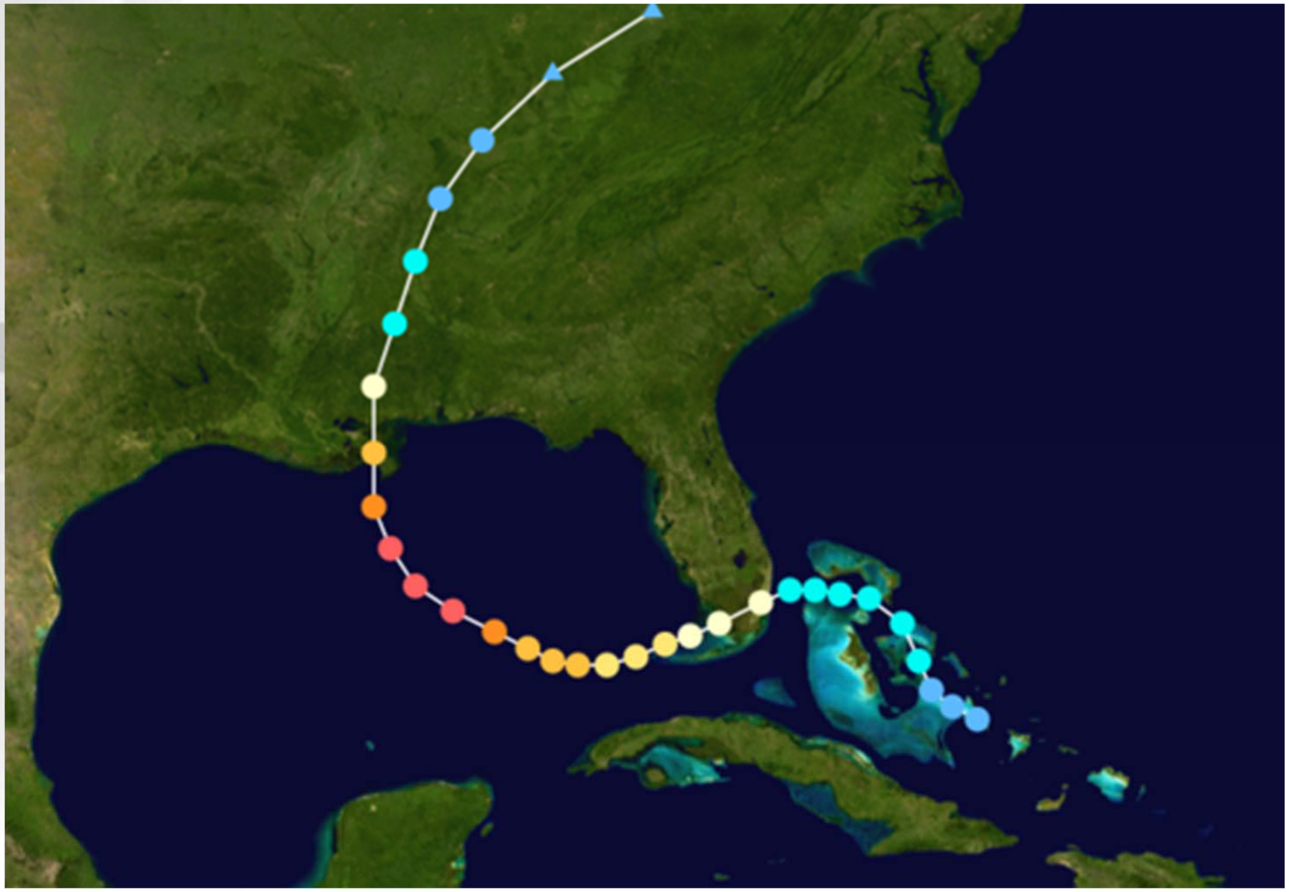
Frequency Blending

- Advantages:
  - It utilizes the simulation approach
  - It outputs event sets for accumulation, helping to reflect dependencies and correlations between portfolios
  - Event sets allows calculations of reinsurance recoveries and reinstatement premiums
  - The blended outputs can be fed directly into capital models for ERM
  –

Challenge of Frequency Blending

- How to vary weight by region and retain the correlations for events impacting multiple regions
- After correlation is broken, annual aggregation will also fail. The application of companywide reinsurance treaty becomes difficult
- Frequency blending requires advanced statistics and programming skills and deeper understanding of models

Challenges of Frequency Blend



Simple/Weighted Average of Loss Cost

- Simple or weighted average of loss cost from different models.
- It is in line with Frequency and Severity Blending
- It can be achieved directly from model output, so the re-simulations of events is not required
- Commonly used in rate making where event loss table and probability of exceedance curve information are not needed.
- Easy to implement and explain to regulators

Selecting Weight by Model Validation

- Review of Model Assumptions
  - Frequency, severity, vulnerability assumptions
  - Geographic relativities
  - Relying on model documentation, modelers submission in different jurisdictions
  - Using notional portfolio to conduct reasonability checks

Selecting Weight by Model Validation

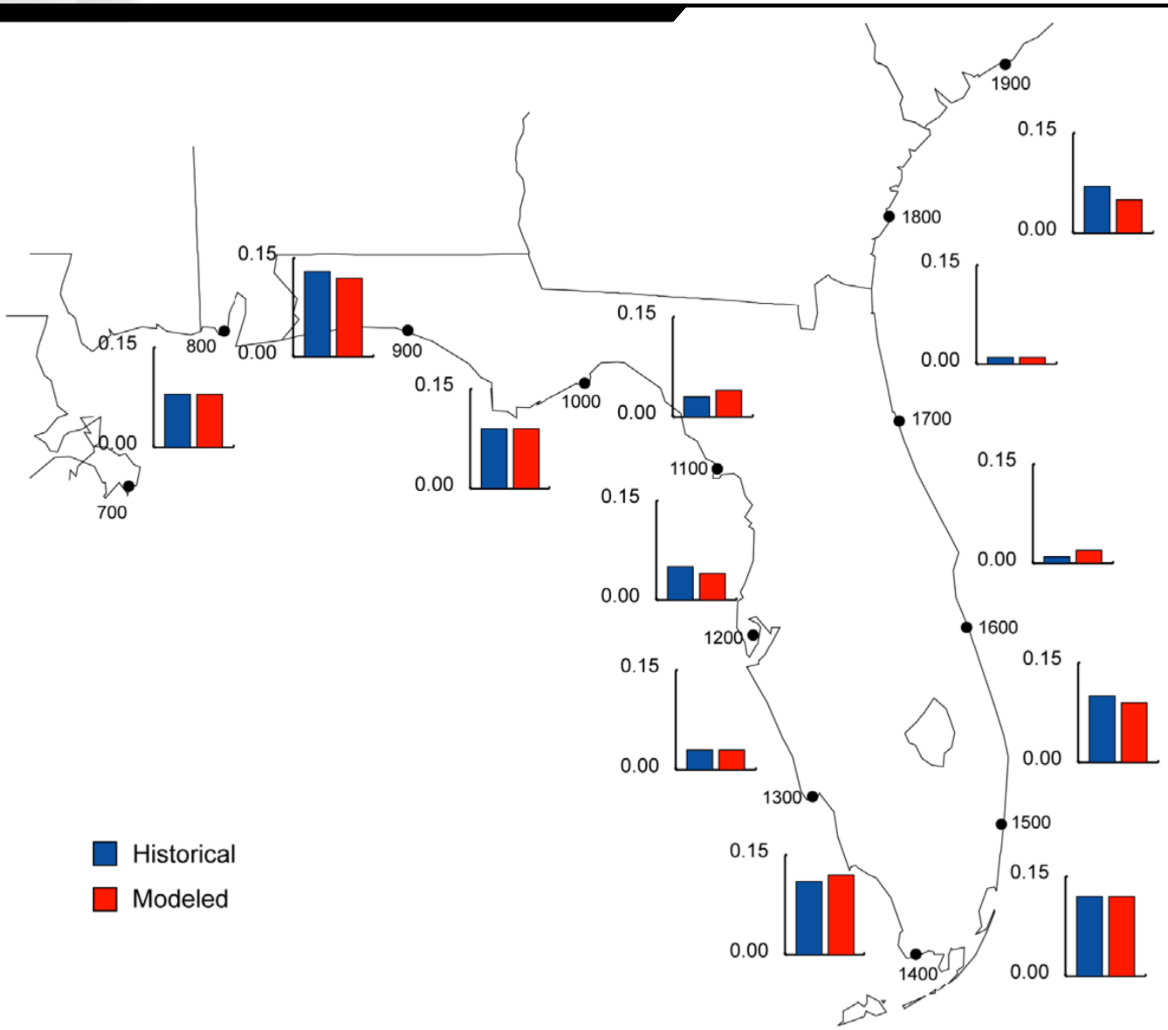
Understand the variations of model assumptions

	Northeast - Long Term Catalog				
	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Model A:	0.058	0.033	0.020	0.003	0.000
Model B.	0.084	0.039	0.020	0.003	0.000
Model C:	0.075	0.040	0.025	0.001	0.000
Model D.	0.046	0.046	0.028	0.003	0.000

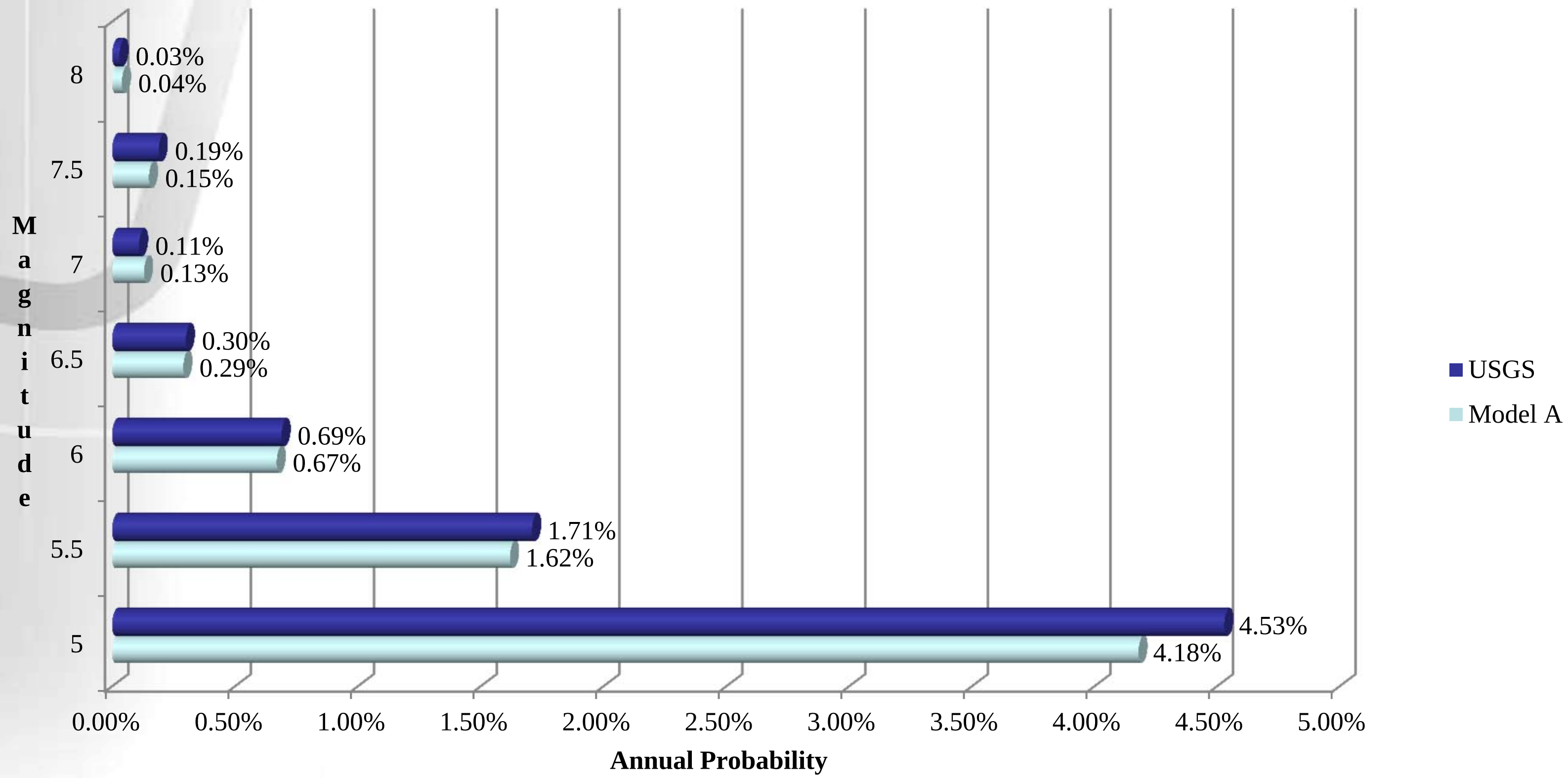
	Florida - Long Term Catalog				
	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Model A	0.266	0.157	0.145	0.066	0.012
Model B	0.258	0.143	0.117	0.048	0.013
Model C	0.299	0.137	0.149	0.083	0.008
Model D	0.313	0.107	0.175	0.078	0.019

- Source: ISCM 2012 RAA Cat Modeling Model Comparison

Compare model assumptions with historical



Compare model assumptions with latest science



Selecting Weight by Model Validation

- Company Specific information
  - Historic events comparison
  - Year to year comparison
  - Comparison of results to other models
  - Reasonableness of relationship among various output results
  - Sensitivity of variations in user input
- Select weighting based on model validation and statistics matrix

Historical Comparison

Hurricane	Exposure	Actual Loss	Modeled loss
Charley	22,275,499,438	63,929,684	105,175,085
Frances	8,964,552,161	56,919,397	31,591,909
Ivan	7,352,146,112	21,126,995	33,776,550
Jeanne	10,715,233,657	11,622,619	24,153,389
Wilma	43,154,867,167	127,121,023	122,399,529
Katrina	7,674,691,708	5,968,809	13,379,694
Total	**100,136,990,243**	**286,688,528**	**330,476,156**

Note: All the exposures and losses have been multiplied by a single constant to disguise the identity of clients.

- Source: AIR Florida 2013 Submission

Model Testing

Comparison # 3
Hurricane = Wilma
Exposure = total (Personal Residential)

Company M	Actual			Modeled		
	Exposure	Loss	Loss/Exposure	Exposure	Loss	Loss/Exposure
Frame	3,760,549,046	868,620	0.000231	3,760,549,046	718,275	0.000191
Masonry	14,965,517,560	12,629,237	0.000844	14,965,517,560	11,261,073	0.000752
Total	**18,726,066,606**	**13,497,857**	**0.000721**	**18,726,066,606**	**11,979,348**	**0.000640**

Note: All the exposures and losses have been multiplied by a single constant to disguise the identity of the client.

Comparison # 4
Hurricane = Charley
Exposure = total (Personal Residential)

Company J	Actual			Modeled		
	Exposure	Loss	Loss/Exposure	Exposure	Loss	Loss/Exposure
Coverage A	5,974,756,996	55,998,569	0.009373	5,974,756,996	40,842,729	0.006836
Coverage C	2,119,645,760	3,897,835	0.001839	2,119,645,760	4,781,987	0.002256
Coverage D	584,167,359	1,388,113	0.002376	584,167,359	1,844,020	0.003157
Total	**8,678,570,114**	**61,284,517**	**0.007062**	**8,678,570,114**	**47,468,736**	**0.005470**

Note: All the exposures and losses have been multiplied by a single constant to disguise the identity of the client.

- Source: AIR Florida 2013 Submission

Blending Beyond Basics

- Model morphing means changing shape. In model morphing, one wants to change some aspect of model A to resemble that of model B, typically, because of implementation difficulties in using both models.
- Model fusion is akin to building one's own model based on own experience and expertise.

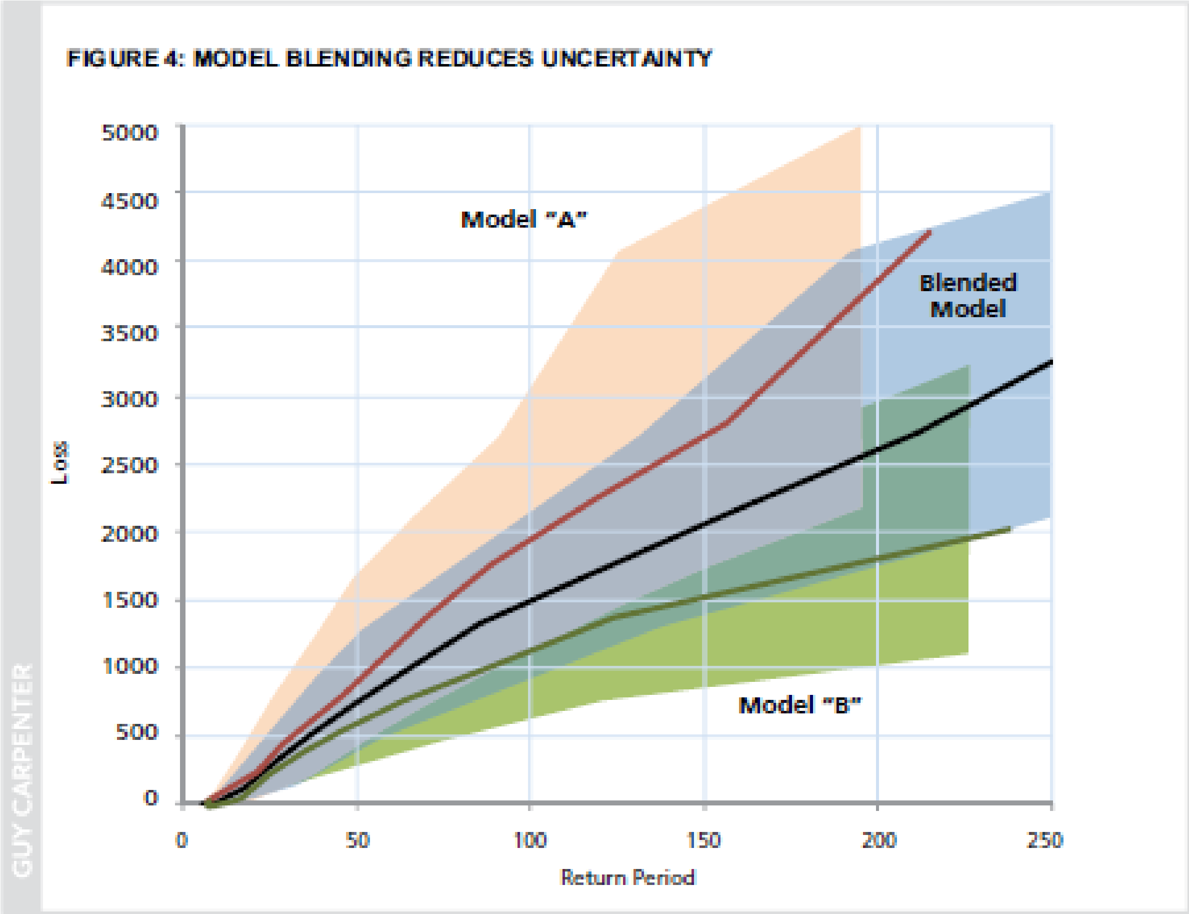
Blending Beyond Basics

- Blending with own loss experience
  - Determine if there is bias by a specific model
  - If there is a bias, then develop a model miss factor
  - Historical information is not enough to calibrate tail distribution
  - Cautions
    - Don't over fit
    - Does the historical information truly reflect the tail? Consider combining multiple distributions.
    - Not recommended for developing loss cost in rate filings

Challenges of Blending

- It is subjective
- The limitations of statistics – stability vs. state of the art science
- False sense of security – Blending doesn’t eliminate the model uncertainty
- Resource and expertise

Model Blending Reduce Uncertainty



Source: Guy Carpenter & Company, LLC

Summary

- Blending models allow companies to include multiple views of the model.
- Blending will mitigate the model uncertainties but will not eliminate the uncertainties. Blending may introduce new uncertainties into the process.
- Blending models requires deep understanding and extensive testing of models.