MOD-3: Managing Severe Thunderstorm Risk

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Taming Cats - Managing Natural and Man-Made Catastrophe Risks

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Baltimore, MD

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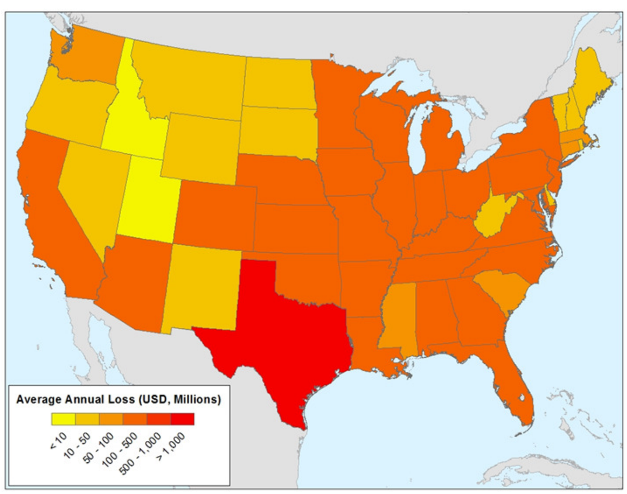
Agenda

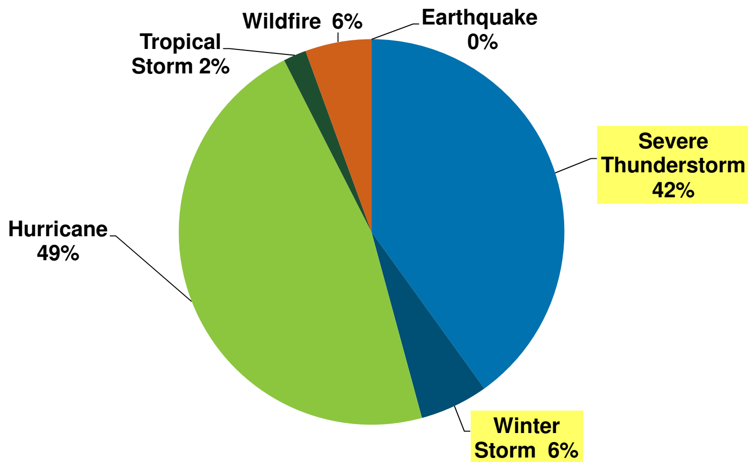
- Introduction
- The value of severe storm models in an insurance organization
  - Overcome limitations of loss experience
  - Understand loss potential in a comprehensive way to prevent "unexpected" loss
- Applications for severe storm modeling
  - Underwriting
  - Pricing
  - Reinsurance structuring
  - Portfolio management / ERM
- Is climate change detectably influencing present day severe thunderstorm activity levels?

All 48 Contiguous States Are Affected by Severe Thunderstorms

PCS Losses, 1990-2011, Trended to 2011 Dollars



Severe Storms Have Accounted for 48% of All U.S. Catastrophe Losses From 2001 to 2011



Source: PCS, trended to 2012

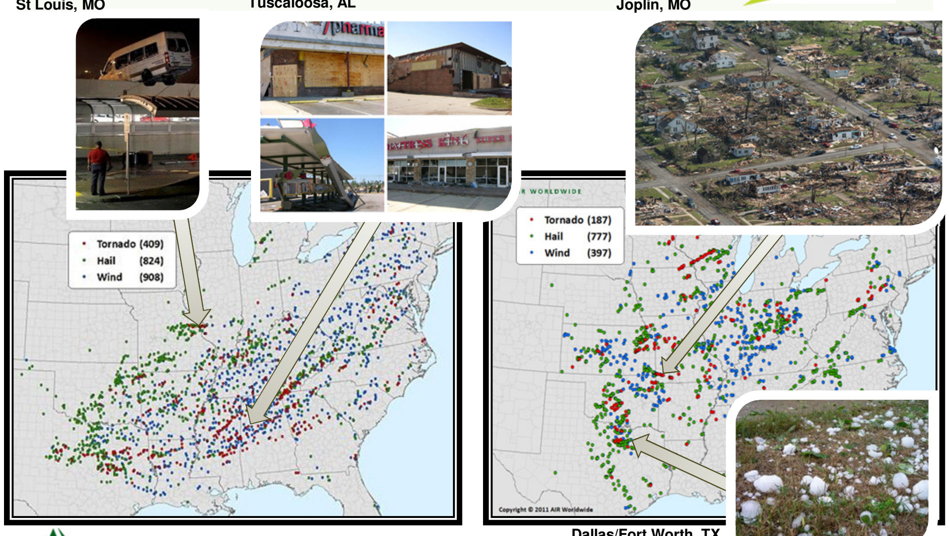
Severe Thunderstorms Can Generate Hail, Tornadoes, and Extreme Straight-line Winds

2011 Was a Record-Breaking Year for Severe Thunderstorm Losses as Reported by PCS

- PCS issued 23 Catastrophe Serial Numbers to severe thunderstorm events in 2011
- 18 events cost over $150 million each
- 5 events cost over $1 billion each
- Maximum reported losses
  - $7.3 billion from Apr 22 – 28 storms affecting AL, AR, GA, IL, KY, LA, MO, MS, OH, OK, TN, TX, VA
  - $6.5 Billion from May 20 – 27 storms affecting AR, GA, IA, IL, IN, KS, KY, MI, MN, MO, NC, NE, NY, OH, OK, PA, TN, TX, VA, WI
- Total losses from severe thunderstorms in 2011 exceed $26.1 billion
- The frequency, severity, and location of thunderstorms in 2011 led to significant losses

The Two Major 2011 Outbreaks as Examples of a Severe Thunderstorm Event

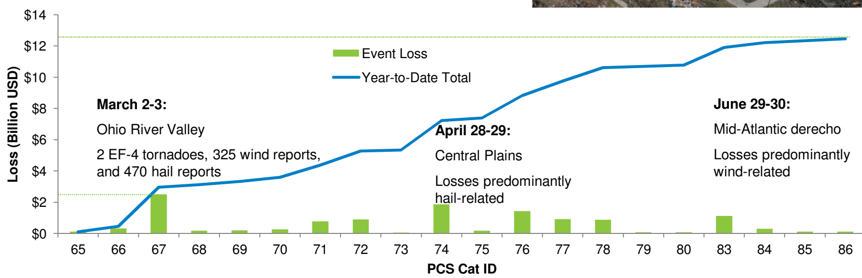
St Louis, MO Tuscaloosa, AL Joplin, MO



Dallas/Fort Worth, TX
St Louis, MO
Kansas City, KS

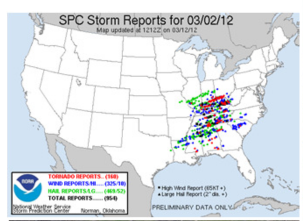
The 2012 Season Has Progressed Very Differently Than the 2011 Season

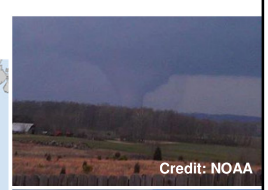
- PCS issued 20 Catastrophe Serial Numbers to severe thunderstorm events
- Losses are dominated by a few main events, with 50% of the total season-to-date loss from three events
- Year-to-date insured losses of $12.45 billion are near modeled AAL
- Significant additional losses are not likely

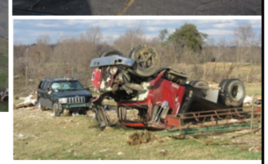


March 2nd – 3rd Tornado Outbreak Has Been the Costliest Severe Thunderstorm Event of the Year

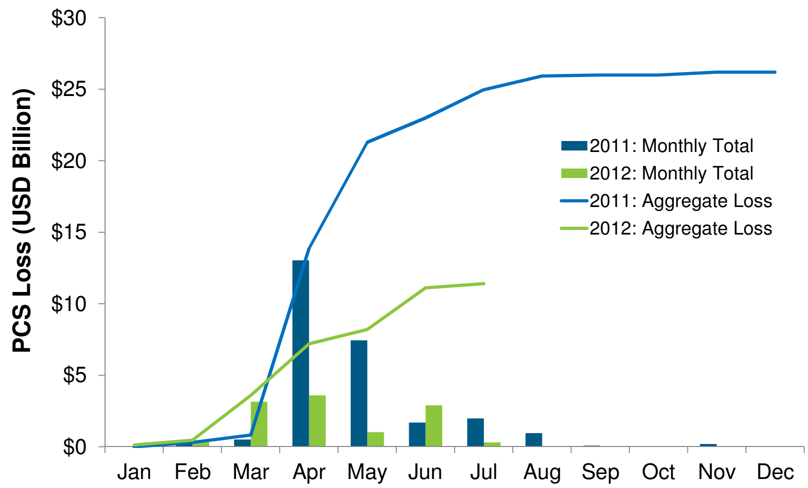
- Most of the activity occurred with the passage of a strong spring low pressure system on the afternoon of March 2nd
- 160 tornadoes, including two EF-4 events impacting Indiana
- 325 high wind reports
- 469 hail reports
  - Largest hail was 108 mm in diameter
- 40 fatalities
- USD 2.5 B of insured losses



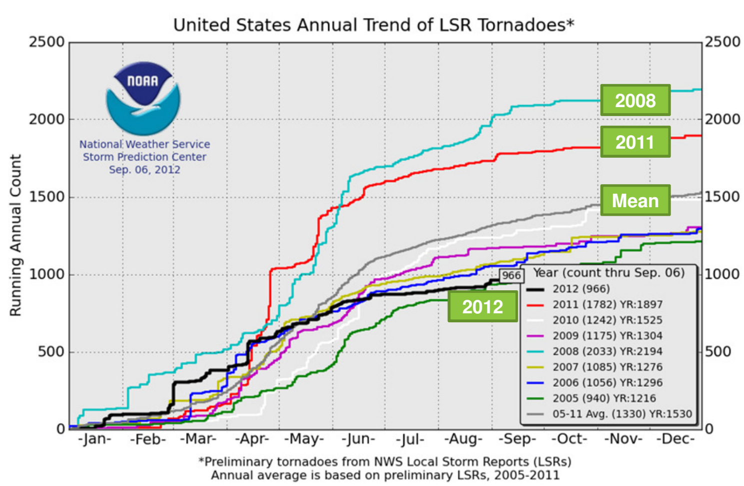




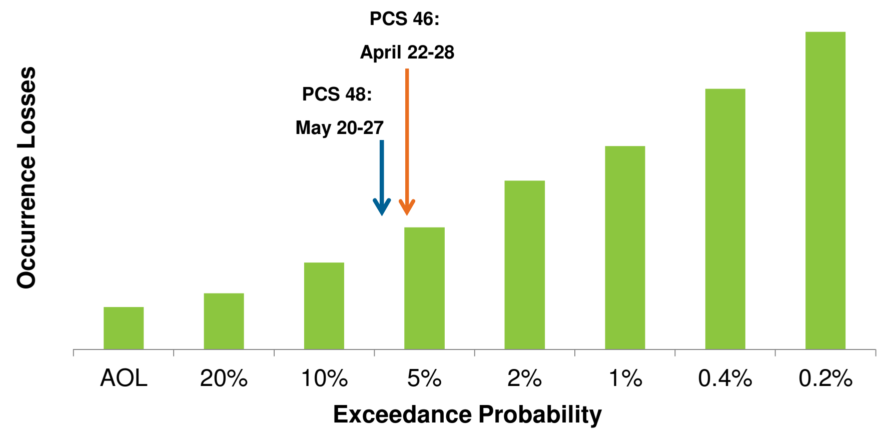
Losses in 2012 Have Accumulated Very Differently Than Those From 2011



Comparison of Recent Seasons Relative to Seven-Year Average Tornado Experience



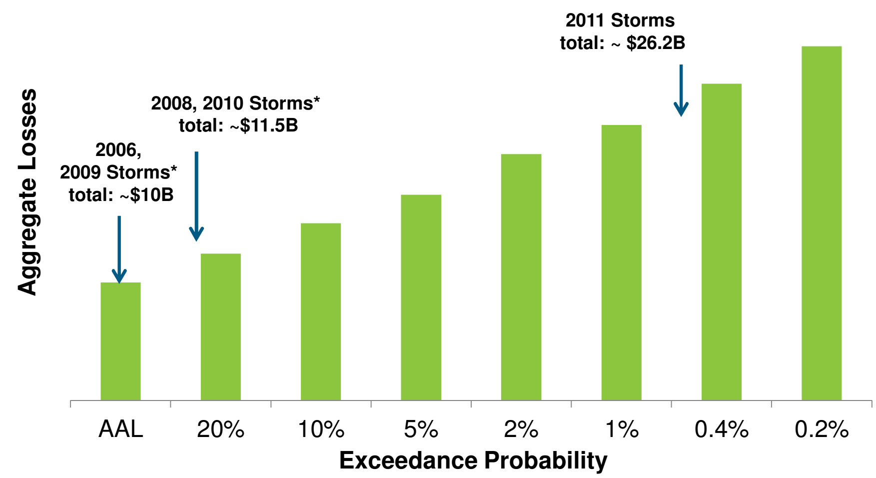
Occurrence Losses from the Major Severe Thunderstorm Events of 2011 Were Not Extreme Outliers



Note: Version 14 with 2011 exposure

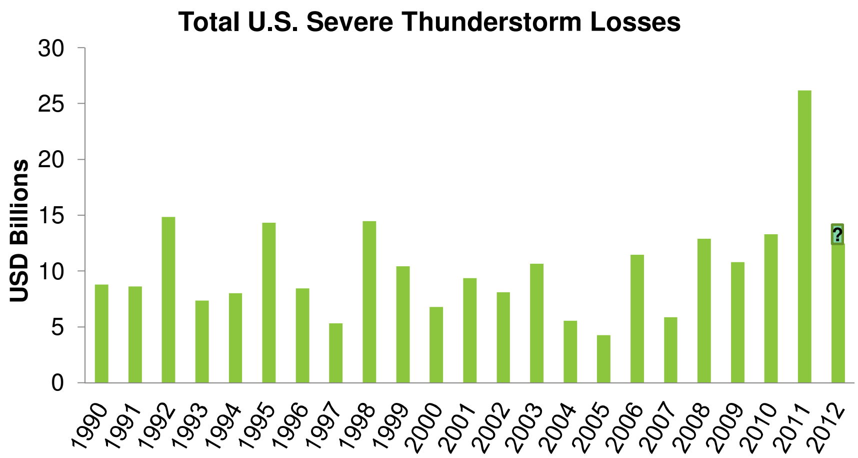
Cumulative Losses from Severe Thunderstorms in 2011 Have an Exceedance Probability of About 0.5%

Losses from Storms in 2000, 2001, 2002, 2003, 2004, 2005, 2007 are < than AAL*



Note: Version 14 with 2011 exposure. PCS historical losses are trended to present

In the Context of the Past 20 Years of Data, 2011 Appears to Be an Anomaly, Not a New Norm



The Enhanced Fujita (EF) Scale Rates Tornado Intensity Based on Observed Damage

- Damage depends on path length, width and wind speed of the tornado
- Intensity varies along the tornado path
- Wind-borne debris and torsion stress act as additional damaging factors
- Wind speeds are derived from EF-Scale, not the other way around
- Damage indicators have been better calibrated in enhanced scale

F0 – F1	F2 – F3	F4 – F5
Minimal to Moderate Damage (Roofs peeled off)	Considerable to Severe Damage (Roofs and some walls torn off)	Catastrophic Damage (Well-constructed structures leveled)

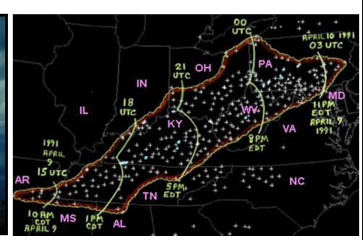


Modeling Hail: Intensity and Area

- Hail is produced in a cumulonimbus cloud when frozen raindrops grow by accumulation
- Hail impact energy a function of
  - Hailstone size
  - Number of hailstones per unit area
  - Hail duration
  - Wind speed

Damaging Straight-line Winds Can Have a Wide Range of Spatial and Temporal Scales

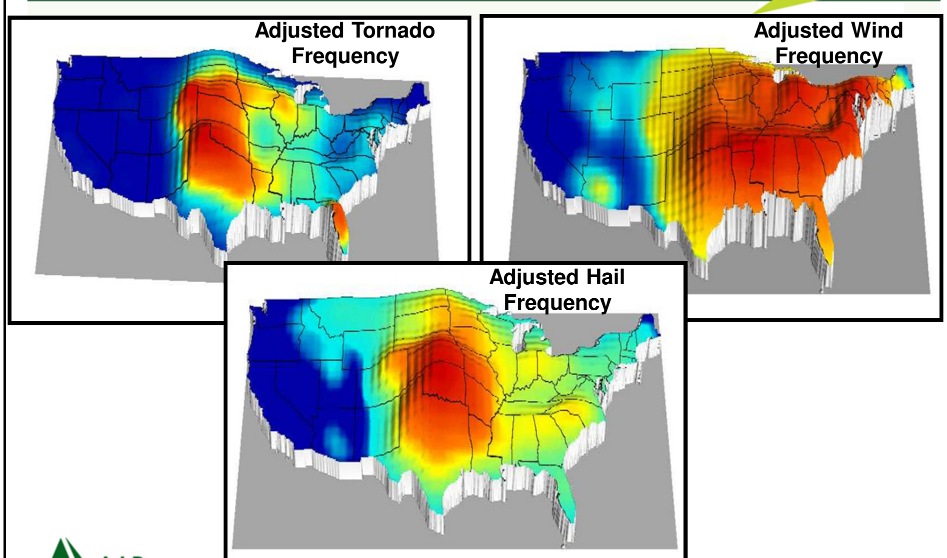
- Downburst winds within the storm can have a coverage of a few square miles and occur over a time period of about one hour or less
- Squall lines spread out quickly ahead of an organized line of thunderstorms, cover an area of hundreds of square miles, and have a duration of several hours
- Derecho are extensive wind events that are associated with long lived convective storm complexes that can cover thousands or tens of thousands of square miles and have life spans of up to a day



Historical Data from the Severe Thunderstorm Database Are Used to Generate the Model Event Set

- Severe Thunderstorm Database maintained by the Storm Prediction Center (SPC), which is part of NOAA
- Information based on reported sightings available starting from the 1950's
- Over 250,000 events since 1974, including more than:
  - ✓ 25,000 tornadoes
  - ✓ 100,000 hail storms
  - ✓ 130,000 wind storms
- The historical data are grouped by AIR into macro events based on geographic distribution and date of occurrence resulting in more than 2,400 historical macro events
- The distribution of population creates biases in the reporting of tornadoes, hail, and straight-line winds

Adjusted Storm Frequencies by Peril Following Data Augmentation and Smoothing



The Value of Severe Storm Models to an Insurance Organization

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Models Are a Practical Solution for Managing Severe Thunderstorm Risk

- Eliminate historical event and claim reporting bias
  - Simulated storms can occur where no historical storms have been reported
- Account for severe thunderstorm loss volatility
  - 10,000-year catalog contains 400,000+ severe thunderstorm events and 65,000+ winter storm events
  - Events modeled include the range of low to high frequency, high to low severity catastrophes
- Enable users to evaluate scenarios for portfolio management
  - Growth and retraction, including acquisitions or divestitures
  - Changing mix of lines of business
  - Optimization of wind pool usage

> "The reality is, any city can be hit by a tornado. If you have sufficient moisture in the atmosphere, instability, some lifting mechanism and the proper wind patterns as they go up into the atmosphere, you can get a tornado. Those conditions tend to be more common in some areas than others, but the fact is, they can arise just about anywhere."
>
> *- Prof. Kenneth Blumenfeld, University of Minnesota*

Reasonable Expectations of Severe Thunderstorm Catastrophe Models

- Expected losses and distributions of potential losses down to a granular scale
- As severe thunderstorm risk is an "aggregate" issue, AIR's simulation year methodology enables appropriate quantification of loss potential within simulated years
- Every year and event is a scenario, which can be used in understanding the range of potential outcomes and drivers of risk
- While the model is comprised of simulated events and years, the primary outputs are distributions of potential *losses*

Severe Thunderstorm Models Capture the Range of Potential Losses from Catastrophic Events

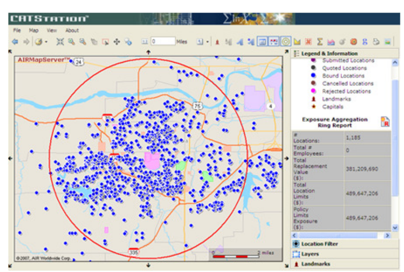
- Care should be taken in validating modeled losses
  - Validation should only consider catastrophic events
  - The model includes tail scenarios that have not yet occurred
  - The granular nature of the peril contributes to the volatility in losses and yields, not surprisingly, disagreements between actual and modeled losses
- Modeled losses for catastrophic events must be combined with actual losses from non-catastrophic events in order to get a complete view of the risk from severe thunderstorms

Severe Thunderstorm Models Can Help Companies Answer a Number of Real World Questions

- Where are my concentrations of exposure?
- What components of the portfolio are driving severe thunderstorm risk?
- What range of potential losses can be expected from severe thunderstorms?
- Is severe thunderstorm risk being considered in the overall catastrophe risk profile?
- Should steps be taken to insulate from severe thunderstorm risk? If so, what actions are appropriate?
- Are the severe thunderstorm components of rates sufficient?

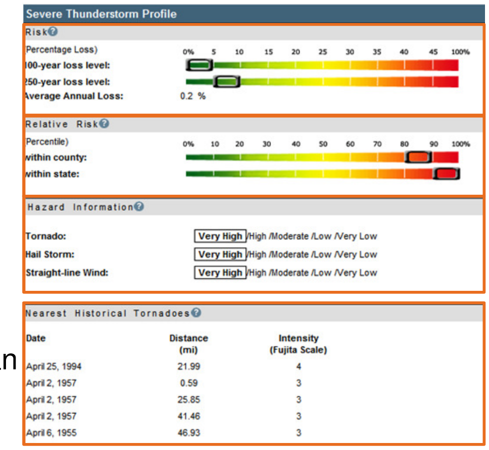
Actively Manage Exposure Accumulations for Severe Thunderstorm

- Exposure accumulations are reviewed for hurricanes and earthquakes. Why not severe thunderstorm?
- 95% of Greensburg, KS was destroyed in an EF5 tornado in May, 2007. The remaining 5% was severely damaged.



Hazard Profiles Provide Invaluable Information to Help Manage Severe Storm Risk

- The Severe Thunderstorm and Winter Storm Hazard Profiles provide
  - Risk scores
  - Relative risk
  - Relative annual frequency
- The Severe Thunderstorm Profile also identifies historical events within 50 miles of the location
- If properties reach a certain threshold of risk, insurers can run a more extensive loss analysis before making the final underwriting decision

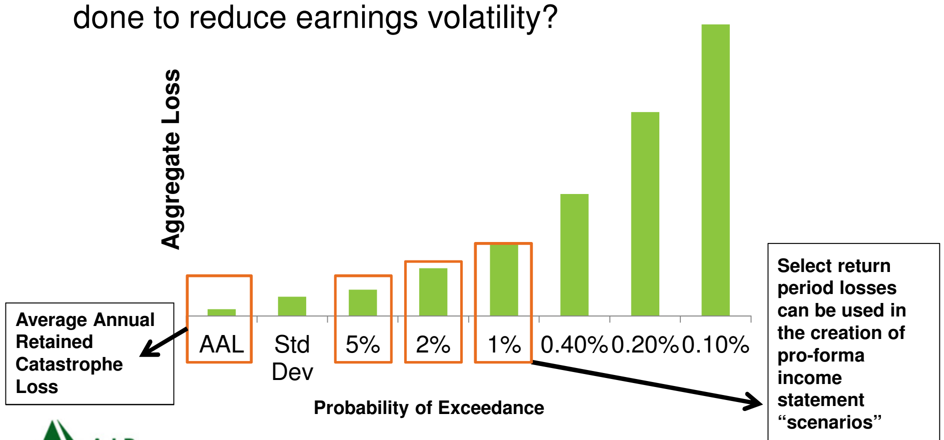


Models Can Be Used to Identify Components of the Portfolio That Are Driving Severe Thunderstorm Risk

State and County	% of Total TIV	Rank TIV	% of Total AAL	Rank AAL	% of Total 1% TVaR	Rank 1% TVaR
Bergen, NJ	2.9%	1	2.4%	2	8.0%	1
Travis, TX	2.1%	2	2.1%	3	7.4%	2
Cuyahoga, OH	1.7%	7	2.1%	4	4.8%	3
Suffolk, NY	2.3%	3	2.7%	1	3.7%	4
Coweta, GA	1.1%	16	1.6%	9	3.7%	5
Baltimore, MD	1.7%	8	1.8%	6	3.5%	6
Oklahoma, OK	0.7%	4	1.8%	5	3.5%	7
Dallas, TX	1.6%	11	1.6%	8	3.1%	8
Lackawanna, PA	1.7%	9	1.5%	11	2.9%	9
Fairfield, CT	1.2%	14	1.0%	14	2.6%	10

Severe Thunderstorm Models Provide Insights into the Range of Potential Incurred Losses

- Does all of this risk go to the bottom line?
- What can these losses do to my earnings and what can be done to reduce earnings volatility?



Modeled Severe Thunderstorm Losses Should Be Included When Considering an Overall Catastrophe Risk Profile

	AAL	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
Earthquake	27,120,338	158,879,967	264,089,927	405,934,077	742,971,254	983,646,511	1,141,000,940
Severe Storm	60,308,841	196,058,211	312,291,274	504,203,661	715,506,615	960,019,277	1,166,591,807

	AAL	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

Severe Thunderstorm Models Facilitate the Evaluation of 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 Winter Storm
$10M	Texas Severe Thunderstorm
$10M	Upper Midwest Winter Storm

$200M + in Aggregate Severe Storm Losses

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

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

Severe Thunderstorm Impacts Aggregate

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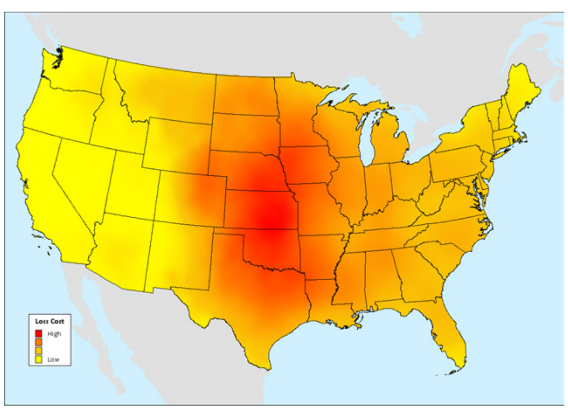
Is My Company Getting Sufficient Rates in Different Geographies?

- Do rates appropriately consider tail scenarios?
- Do rates reflect the variability of risk at an appropriate level of geographic granularity?



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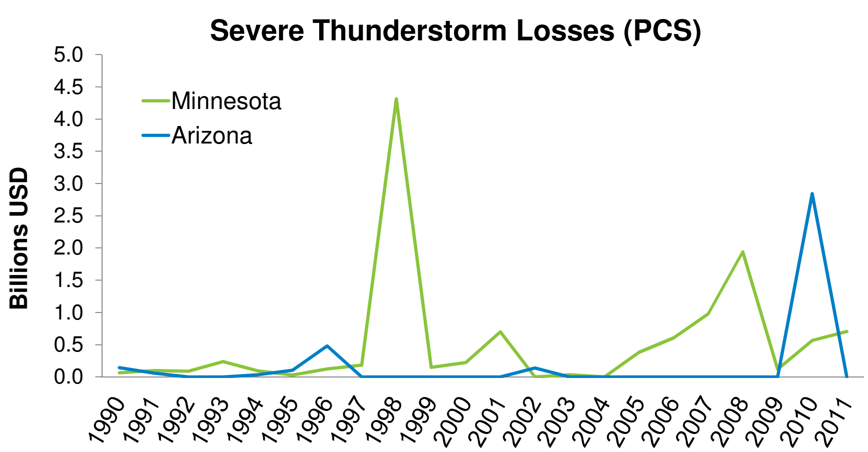
The Variability in Severe Thunderstorm Losses Poses Challenges for Ratemaking

- Severe thunderstorm losses can be variable and substantial

> "*A rate provides for all costs associated with the transfer of risk.*"
>
> **- CAS Statement of Principles Regarding Property and Casualty Ratemaking**

- Companies often perceive they have sufficient data for severe thunderstorm risk
- Traditional approaches are unlikely to capture the tail risk associated with severe thunderstorm peril
- In order to avoid shifts in loss costs caused by volatility in loss experience data, "expected" non-hurricane catastrophe losses should be used in place of actual non-hurricane cat losses experienced over a short time period

Loss Volatility Is Amplified at Higher Levels of Geographic Resolution

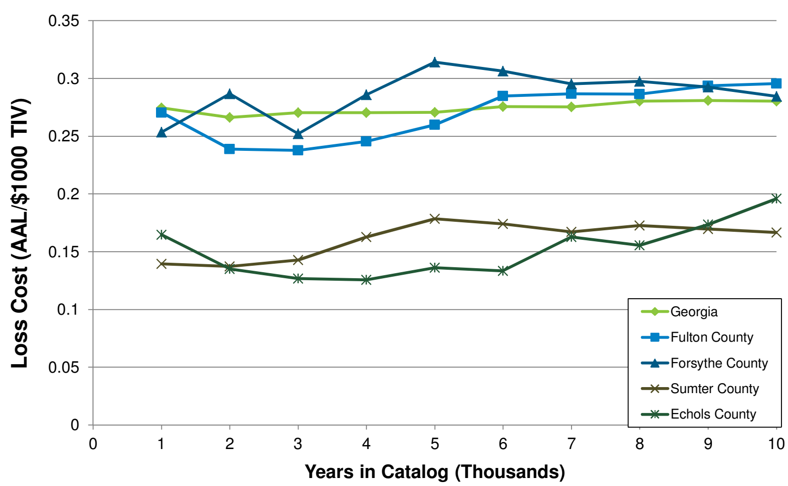


Source: PCS, trended to 2011

Sound Ratemaking Requires a Method to Account for Severe Thunderstorm Losses

- Many companies are using the ISO excess wind procedure (or an internally developed variation)
- Wind load factor can be developed using historical loss data, but there are limitations to this method
  - Requires data for a long time period
  - Does not reflect make up of current exposure distribution
  - Does not consider more extreme high-severity losses
- Superior method utilizes modeled losses
- Two main components to these approaches:
  - Determine what losses to remove from experience data to avoid double counting
  - Develop a sound method to add back in the loss potential

Severe Thunderstorm Model Is Appropriate for Use at the State and County Levels



Results are based on a sample company's actual exposure in Georgia

Modeled Loss Costs Are Combined with Actual Non-Catastrophe Losses

Raw Model Output

LocationID	AreaLevel2Name	AreaLevel3Name	AreaLevel4Name	GUAAL	GRAAL
1	Kansas	Morton	67953	134	127
10	Kansas	Stanton	67862	144	136
100	Kansas	Morton	67950	157	149
1000	Kansas	Stevens	67951	157	148
1001	Kansas	Stevens	67951	164	156
1002	Kansas	Stevens	67951	122	114
1003	Kansas	Stevens	67951	130	122

Model AAL by Geography

ZIP CODE	AAL
67838	27,958
67846	7,166
67851	23,029
67855	50,845
67857	36,483
67860	19,648
67861	8,947
67862	20,476
67870	8,250
67877	8,104
67878	74,209
67879	7,761
67880	117,990
67950	25,145
67951	58,449

Claims Data

YEAR	PCS CAT NUMBER	ZIP CODE	GROSS INCURRED
2006	46	67855	60,500
2006	46	67953	33,265
2006	-	67951	21,200
2006	-	67954	11,050
2006	47	67838	32,450
2006	47	67846	54,780
2006	45	67880	14,350
2006	57	67952	18,900
2006	56	67950	65,700
2006	-	67857	3,600
2006	67	67861	85,650
2005	80	67879	45,600
2005	82	67862	23,025

Non-CAT Avg Loss

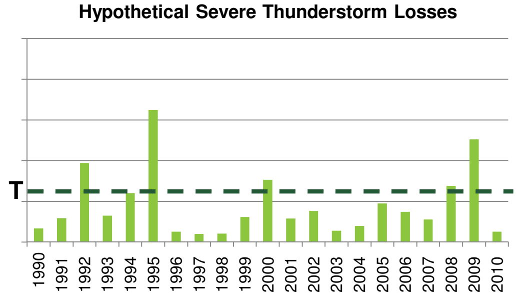
ZIP CODE	AVG LOSS
67855	26,545
67953	8,600
67951	1,650
67954	9,700
67838	4,355
67846	1,247
67880	18,562
67952	10,476
67950	5,754

Rate = Modeled Loss Cost (Excess Loss Cost) + Trended Non-CAT Claims + …

Next Evolution Is to Blend Actual Loss Experience and Catastrophe Modeling Output

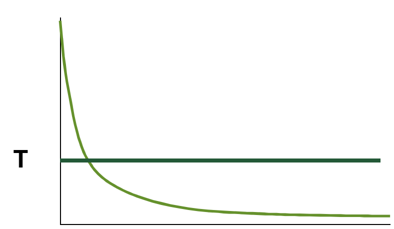
- Use loss experience for catastrophe losses up to a threshold (T) size
- Use modeled loss factor above this threshold
- Rate = Non Cat + (Experience based Cat Load | < T)
  + (Model Cat Load | >T) + …

Hypothetical Severe Thunderstorm Losses



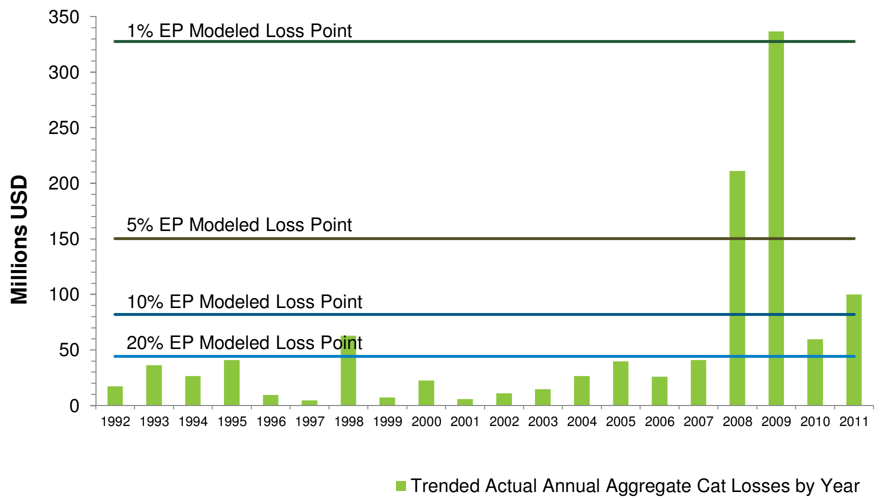
Actual Trended Loss Experience

Exceedance Probability Curve



Modeled Loss Potential

Georgia Company Example: Annual Aggregate Catastrophe Claims By Year

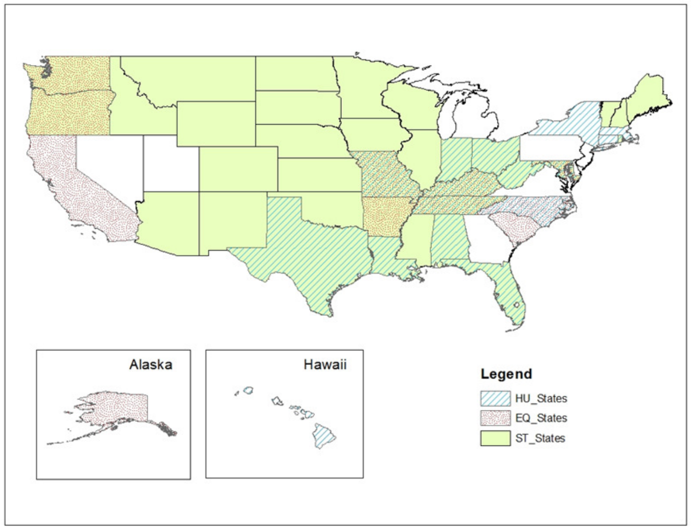


*Company data includes Georgia exposures only

Georgia Company Case: Producing Loss Cost Based on Modeled and Observed Experience

Scenario	Earned House Years (000's)	Non-CAT AAL ($M)	A: Non-CAT Loss Cost (AAL/EHY)	B: Experience Based Catastrophe Load (Sum {Wind Loss<T/Total Loss})/20	C: Modeled Catastrophe Loss Cost (AAL/EHY)	A(1+B) + C Total Loss Cost
Actual CAT Losses Only	330	150	454.55	0.366626	0.00	621.20
Excl. Losses >5% EP Point (T=$150M)	330	150	454.55	0.284259	38.43	622.18
Excl. Losses > 10% EP Point (T=$82M)	330	150	454.55	0.2322670	52.94	613.25
Excl. Losses > 20% EP Point (T=$44M)	330	150	454.55	0.183478	68.88	606.83
Modeled Losses Only	330	150	454.55	0.0	136.66	591.21

AIR's Severe Storm Models Are Increasingly Relied Upon to Support Rate Filings in Many States



Functional Areas in which Modeling Severe Storm Losses Can Add Value for Insurers

Functional Area	Description
Underwriting	• Hazard, exposure concentration, and loss analysis for severe storm used to inform risk selection
Portfolio Management	• Manage concentrations of risk to severe storms
Ratemaking/Pricing	• Use model outputs in conjunction with historical loss data in pricing to prevent volatility at a granular level (i.e. territory)
Reinsurance Structuring	• Understanding severe storm risk can help companies structure reinsurance treaties, particularly aggregate or second / third event covers
Enterprise Risk Management	• Severe storm losses result in volatility to the income statement, and impact can be great because losses are not commonly reinsured

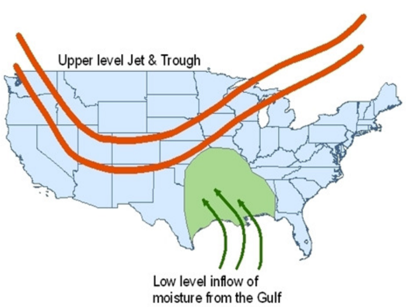
Questions of Concern to Many U.S. Insurers

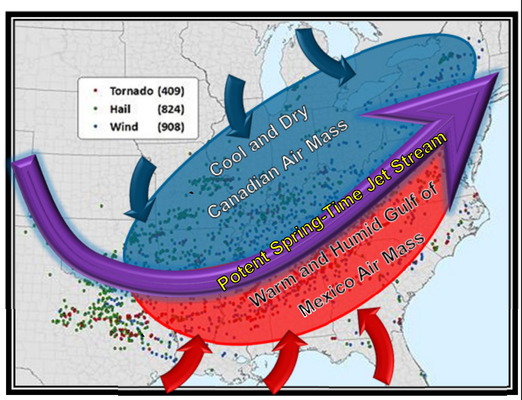
- Is U.S. severe thunderstorm risk increasing?
- What is the impact of climate change on severe thunderstorm risk?
  - Is there a detectable signal?
  - Is the underlying data dependable?



The 2011 Outbreaks Formed Under Persistent, Large Scale Conditions Favorable for Severe Thunderstorms

- Key Ingredients for development and evolution of severe thunderstorms and tornadoes are known
  - Upper level jet stream intensity
  - Low level inflow of moisture





Climate Factors Can Influence These Conditions

- **ENSO (**El Niño-Southern Oscillation) - affects position of upper tropospheric jet stream, which in turn affects synoptic patterns across continental U.S. and impacts regional events. El Niño, for example:
  - Leads to an anomalous upper level high over central U.S.
  - Suppresses low level flow from Gulf of Mexico

  Both these effects inhibit the occurrence of severe weather
- 2011 featured a weakening La Niña to neutral conditions which led to a meandering jet stream over U.S. This set-up:
  - Numerous cold air outbreaks which interacted with the warm and moist air coming from the south, which in turn resulted in increased atmospheric instability

  This environment produced favorable conditions for severe weather development
- **Natural Variability** – Severe thunderstorms depend upon complex and chaotic interactions in the atmosphere and therefore are subject to a great deal of year-to-year and day-to-day variability

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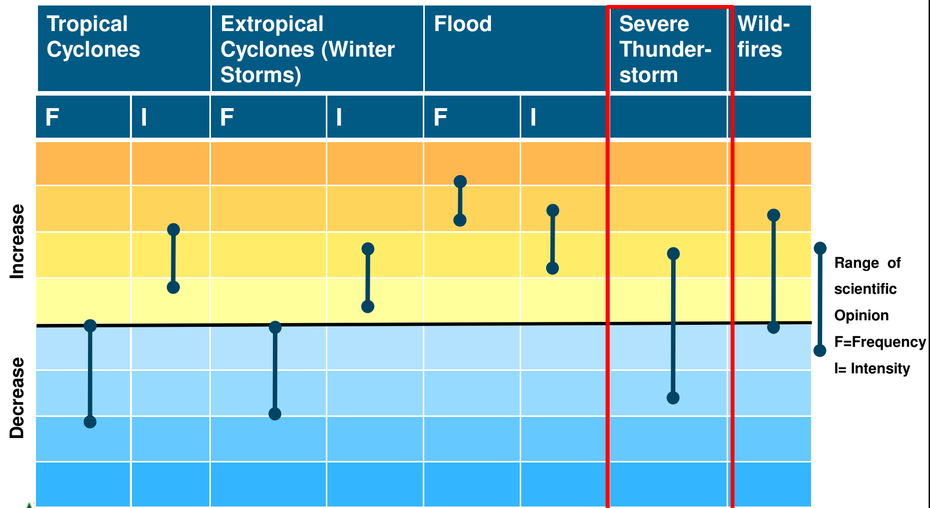
Climate Change Results in Two Competing Mechanisms at Play that Can Alter Severe Thunderstorm Risk

- Overall low level temperature gradients between equator and poles are weakening, in turn causing a weakening of the vertical wind shear
  - This reduces the probability that severe thunderstorms will occur
- Warming at the surface causes an increase in vertical instability and an increase in low-level moisture
  - This increases the probability that severe thunderstorms will occur
- Latest research on the change in risk is inconclusive
  - Trapp et al. (2007): a warming climate might see fewer organized convective storms, but storms that do form probably will be accompanied by more intense precipitation
  - IPCC report (2007): concluded that there are insufficient studies for assessing observed changes in severe weather phenomena
  - Trapp et al. (2009): indicates that overall the net forcing for severe thunderstorms in the US appears to be increasing with higher concentrations of green house gases and increasing temperature

AIR

AIR Continues to Evaluate the Impact of Climate Change on Atmospheric Perils Worldwide



Summary

- Severe thunderstorm events are localized in nature, widespread throughout the US and have produced significant losses
- There are substantial limitations to solely using of historical loss data in managing severe storm risk
- A catastrophe model provides a more reliable view of the risk and can help manage severe storm risk across underwriting, rate-making, risk transfer and portfolio management functions
- No clear signals exist indicating a climatological influence on severe thunderstorm activity, AIR continues to evaluate the impact of climate change on atmospheric perils worldwide