



C-25: Severe Weather Ratemaking

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Casualty Actuarial Society, 2011 Annual Meeting
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Agenda

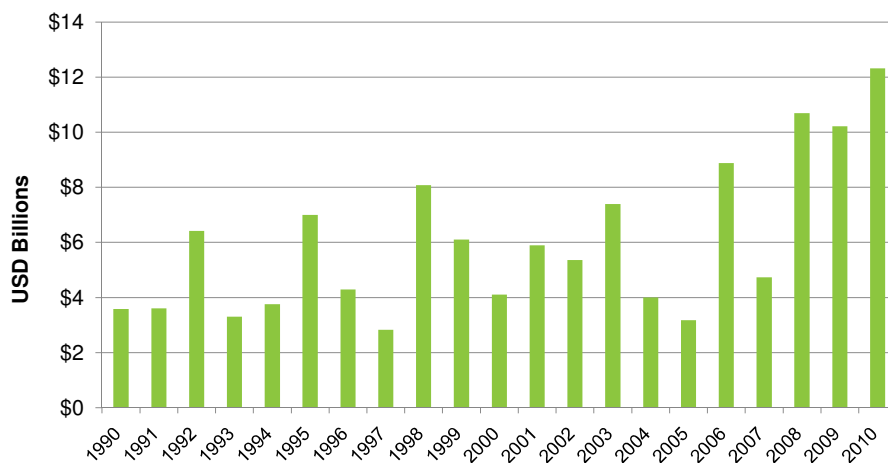
- Introduction
- The value of severe storm models in an insurance organization
 - Overcome limitations of loss experience
 - Understand loss potential in a comprehensive way to prevent “unexpected” loss
- Applications for severe storm modeling
 - Underwriting
 - Pricing
 - Reinsurance structuring
 -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



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Insured Losses from Severe Thunderstorms, 1990-2010



Source: PCS, 2011 dollars

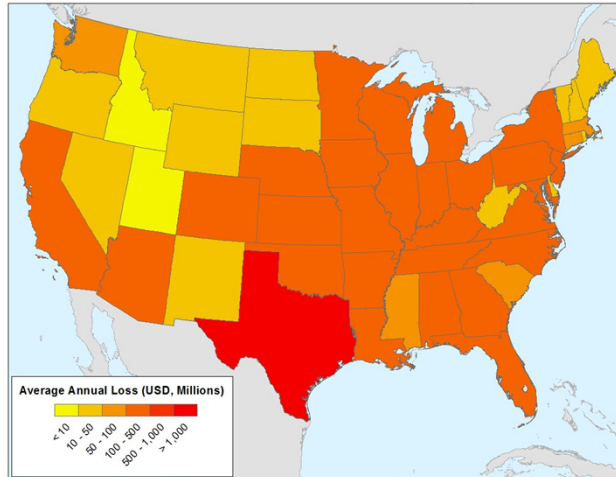


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All 48 Contiguous States Are Affected by Severe Storms

PCS Losses, 1991-2010, Trended to 2011 Dollars

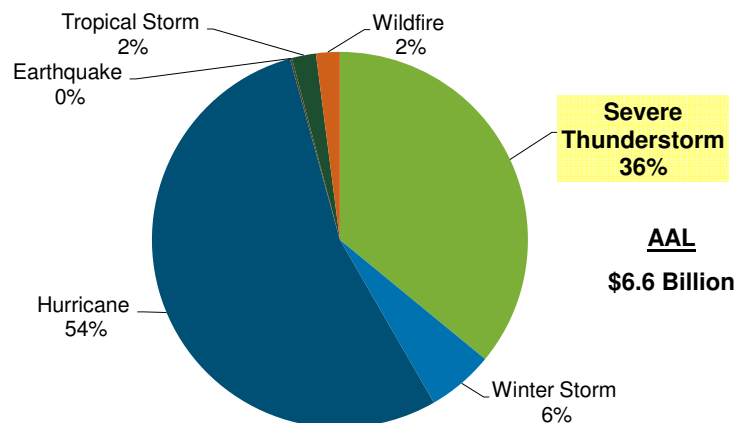


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Severe Storms Have Accounted for 42% of All U.S. Catastrophe Losses Since 2001

U.S. Catastrophe Losses 2001-2010



Source: PCS, trended to 2011



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2011 Has Been a Record Breaking Year for Severe Thunderstorm Losses as Reported by PCS

- PCS has issued 23 Catastrophe Serial Numbers to severe thunderstorm events so far in 2011
- 17 events cost over \$150 million each
- 6 events cost over \$1 billion each
- Maximum reported losses so far:
 - \$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 so far in 2011 exceed \$24.5 billion

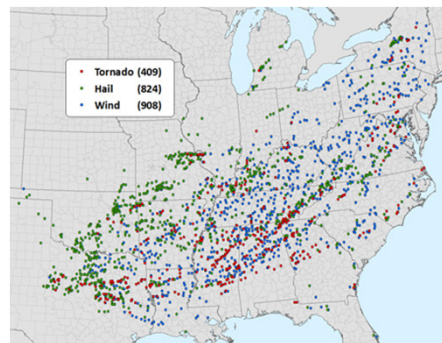


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ALERT Loss Estimates for Severe Thunderstorms Occurring on April 22-28, 2011

- Affected Southern and Southeastern United States
- ISO'S Property Claims Services (PCS)[®] Catastrophe Serial Number 46
- On May 9th, AIR estimated these events resulted in between 3.7B to 5.5B USD in insured losses*



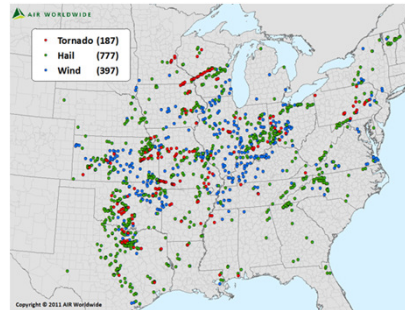
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* The loss estimates do not reflect non-modeled losses, including loss adjustment expenses

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ALERT Loss Estimates for Severe Thunderstorms Occurring on May 20-27, 2011

- Affected Texas, Arkansas, Oklahoma, Missouri, Tennessee, Kentucky, Ohio, Eastern Seaboard
- ISO'S PCS Catastrophe Serial Number 48
- On June 6th, AIR estimated these events resulted in between 4B to 7B USD in insured losses*



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* The loss estimates do not reflect non-modeled losses, including loss adjustment expenses

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What Is a Severe Thunderstorm?

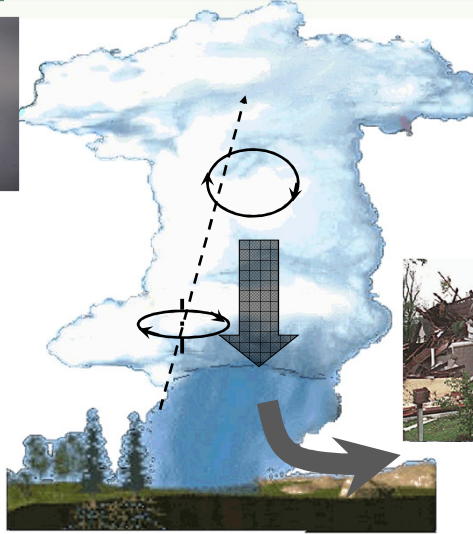
- National Weather Service (NWS) definition
 - A thunderstorm that produces at least one of the following
 - Straight-line winds of at least 50 knots (58 mph)
 - A tornado or funnel cloud
 - Hail at least 1 inch in diameter
- The term microevent refers to individual tornadoes, hailstorms or straight-line windstorms
- A macroevent is defined as a group of individual tornadoes, hailstorms, or straight-line windstorms that occur in one or more days as a result of the same atmospheric event or frontal system
- A macroevent may include several hundred microevents



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



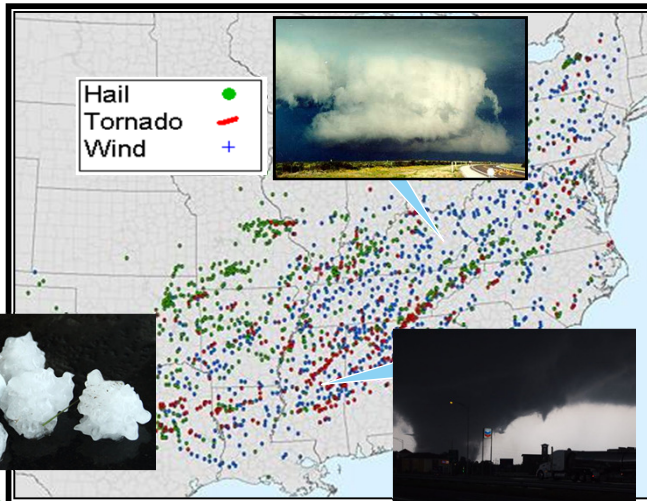
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Severe Storms April 22-28, 2011 Produced More than 2,000 Microevents

Severe Storms April 22-28, 2011

Winds in excess of 100 mph



Hail > 4.5" in size



409 damaging tornadoes



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Challenges of Modeling Tornadoes: Intensity

- Damage depends on path length, width, and wind speed
- Wind speeds are derived from Enhanced Fujita Scale
- Intensity varies along tornado path
- The scale of tornadoes is much smaller as compared to other perils
- Tornadoes exhibit variation in characteristics along their tracks, yet the historical data does not retain much information about this variability



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Typical Tornado Damage

Fujita Scale

Windspeed	Damage Potential	Effect Observed
F-0 (40-72 mph)	Light	Some damage to chimneys...
F-1 (73-112 mph)	Moderate	Peeled surface off roofs...
F-2 (113-157 mph)	Considerable	Roofs torn off houses...
F-3 (158-206 mph)	Severe	Roofs and some walls torn off well-constructed houses...
F-4 (207-260 mph)	Devastating	Well-constructed houses leveled...
F-5 (261-318 mph)	Incredible	Strong frame houses lifted off foundations and carried considerable distance to disintegrate...



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Challenges of 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



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Challenges of Modeling Straight-line Winds: Area Impacted

- Similar problems to those seen with tornadoes
- Less information is provided for straight-line wind events, requiring additional information to be used
- Of particular interest is how much of the area within a wind event actually sustains damage

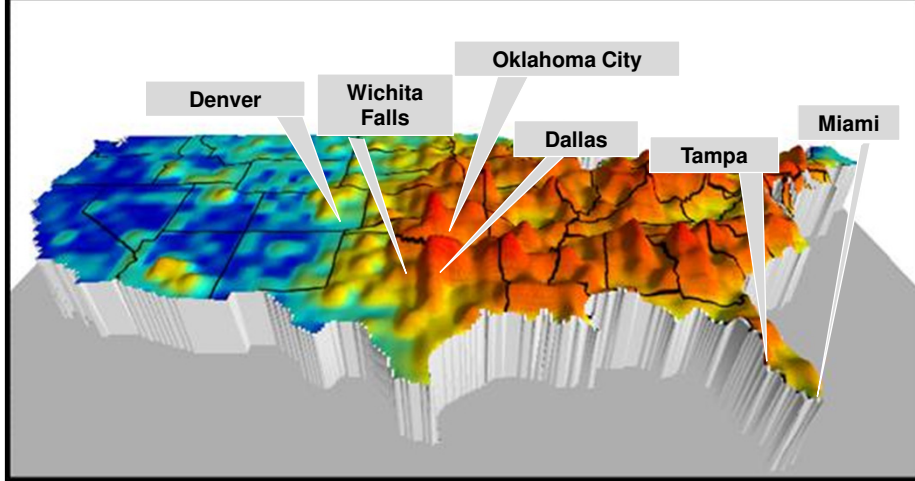


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The Distribution of Population Creates Biases in the Reporting of Tornadoes, Hail, and Straight-line Winds

Reported Instances of Thunderstorm-Induced Straight-line Winds Exceeding 50 knots

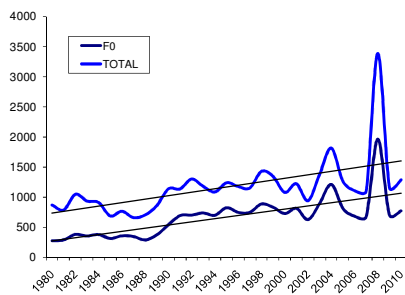


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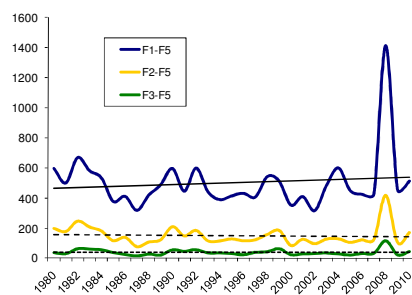
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The Historical Data Must be Cleaned to Remove Reporting Biases

Annual Number of Tornado Sightings



Annual Number of Confirmed Tornado Touchdowns



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Data Smoothing and Augmentation Are Used to Remove These Sampling Issues

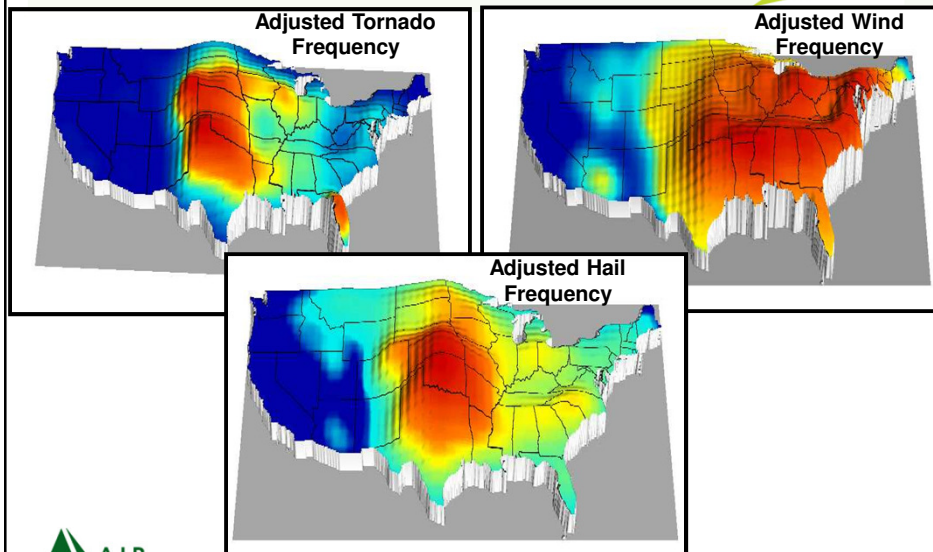
- Kernel smoothing is used to produce a spatially smooth surface of event frequency
- Spatial smoothing fills the valleys but lowers the peaks in areas where the reporting may be more complete
- Data augmentation, in addition to smoothing, is needed for an accurate assessment of risk
- Temporal filling: micro events are added to alleviate time trends
- Spatial filling: the data augmentation is performed in a way that helps remove population biases present in the historical data
- After data augmentation, the smoothed distribution should agree with the historical distribution in areas where the reporting is believed to be accurate and complete



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Adjusted Storm Frequencies by Peril Following Data Augmentation and Smoothing



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Location-Level Exposures Are Recommended for Modeling Severe Storms

- Mainly due to the localized footprints of tornado, hail and straight-line wind microevents in the severe thunderstorm catalog



Tornado Footprint

- Exposure resolutions in order of preference
 1. Location level
 2. ZIP Code Distributed
 3. ZIP Code Aggregated



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The Value of Severe Storm Models to an Insurance Organization



Historical Event Analysis Is Not Sufficient for Managing Severe Storm Risk

- Limited nature of claims data
 - Geographic distribution of historical activity
 - Constantly changing landscape of exposure data
 - New property development
 - Building materials and design practices continue to evolve
- Volatility of historical loss data
 - Frequency: active vs. inactive periods
 - Severity: minor vs. severe event
- Inability to perform sensitivity testing to assess the impact on a portfolio
 - Deductible studies
 - Exposure growth and retraction strategies

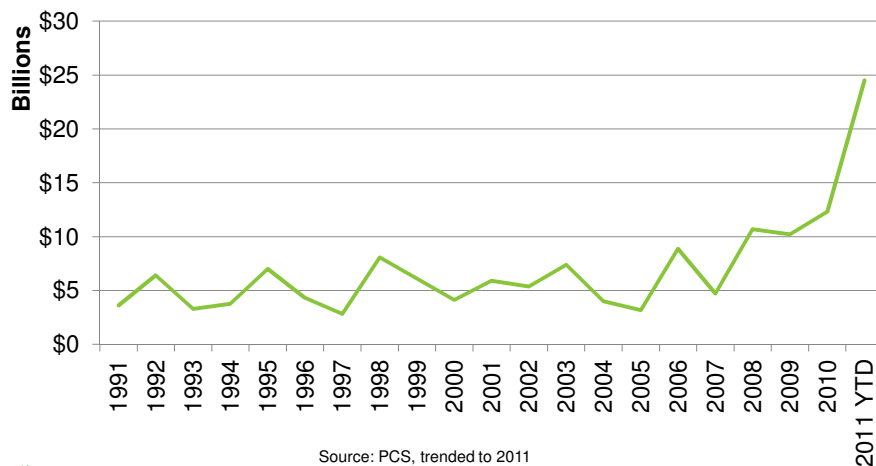


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Severe Storm Losses Are Volatile from Year to Year

Total U.S. Severe Thunderstorm Losses



Source: PCS, trended to 2011

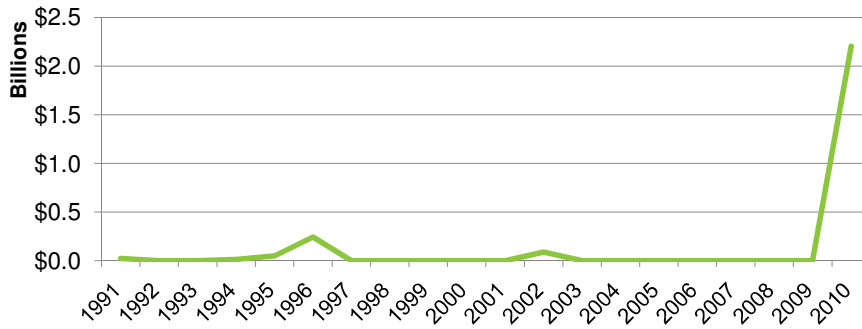


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Loss Volatility Is Amplified at Higher Levels of Geographic Resolution

Arizona Severe Thunderstorm Losses (PCS)

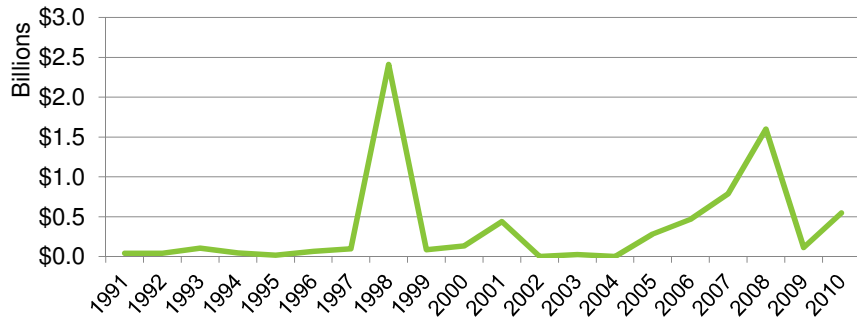


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Loss Volatility Is Amplified at Higher Levels of Geographic Resolution

Minnesota Severe Thunderstorm Losses (PCS)



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Individual Insurers Also Experience Similar Severe Storm Loss Volatility

Example: Insurer Historical Severe Storm Losses



Year-over-year loss changes of 25% to 35%



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Catastrophe Models Are a Practical Solution to a Widespread Problem

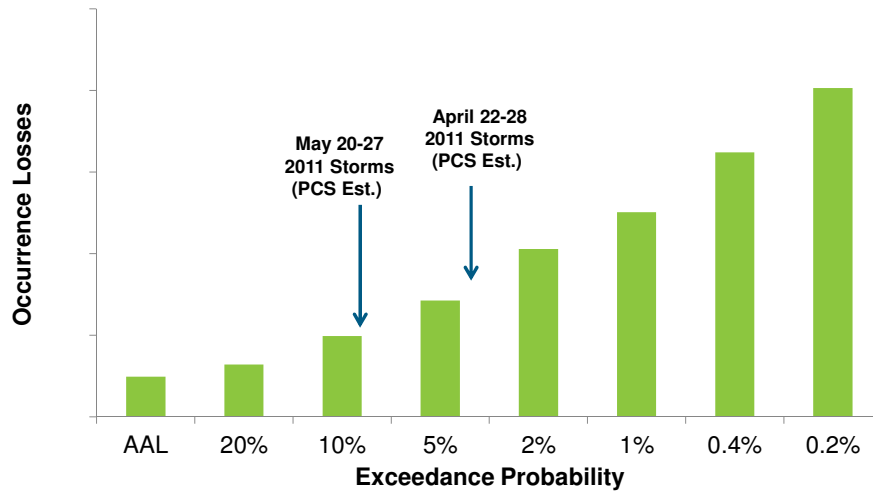
- Eliminate historical event and claim reporting bias
 - Simulated storms can occur where no historical storms have been reported
- Account for severe storm loss volatility
 - 10,000-year catalog contains 400,000+ severe thunderstorm events and 65,000+ winter storm events
 - Events modeled include the range of low to high frequency, high to low severity cat events
- Evaluate scenarios for portfolio management
 - Growth and retraction
 - Acquisitions of books of business
 - Changing mix of lines of business



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Two Significant Clusters of Severe Thunderstorms in 2011

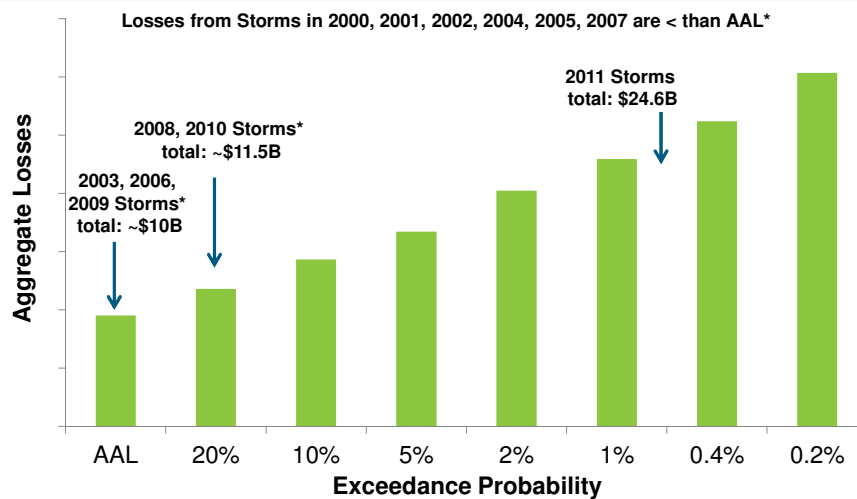


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* Trended to Present Dollars

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Cumulative Losses from Severe Thunderstorms in 2011 Have an Exceedance Probability of Slightly under 1%



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* Trended to Present Dollars

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AIR's Severe Thunderstorm Catalog Contains Years that Resemble Losses of 2011

Year 8898	Total Losses: \$21.7 Billion
Northeast Severe Thunderstorm	\$216M
Upper Midwest Severe Thunderstorm	\$323M
Southeast Severe Thunderstorm	\$2,109M
Midwest Severe Thunderstorm	\$149M
Midwest Severe Thunderstorm	\$7,793M
Texas Severe Thunderstorm	\$162M
Southwest Severe Thunderstorm	\$94M
Midwest Severe Thunderstorm	\$84M
Midwest Severe Thunderstorm	\$9,201M
Plains Severe Thunderstorm	\$51M
Southwest Severe Thunderstorm	\$175M
Upper Midwest Severe Thunderstorm	\$77M
Upper Midwest Severe Thunderstorm	\$162M
Upper Midwest Severe Thunderstorm	\$116M
Upper Midwest Severe Thunderstorm	\$132M
Texas Severe Thunderstorm	\$78M
Midwest Severe Thunderstorm	\$93M
Upper Midwest Severe Thunderstorm	\$292M
Southeast Severe Thunderstorm	\$75M
Gulf Severe Thunderstorm	\$56M



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Using Single Peril Analyses Will Lead to 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
Earthquake						
27,120,338	158,879,967	264,089,927	405,934,077	742,971,254	983,646,511	1,141,000,940
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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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 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

Severe Thunderstorm impacts aggregate

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



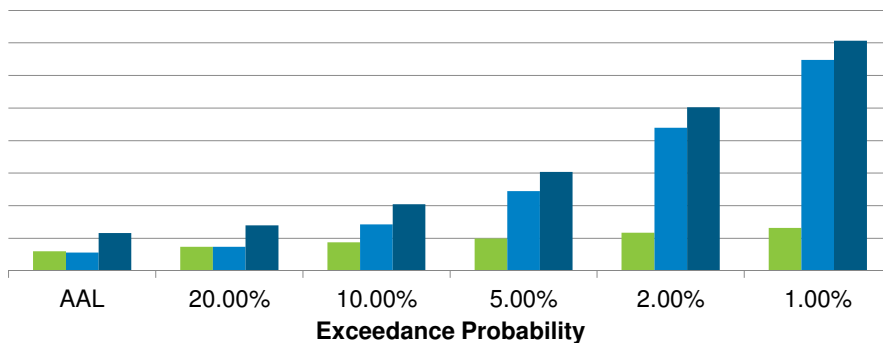
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Comparison of Severe Storm Losses to Hurricane Losses

U.S. Industry Summary EP Curve

■ Severe Storm ■ Hurricane ■ Hurricane + Severe Storm



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

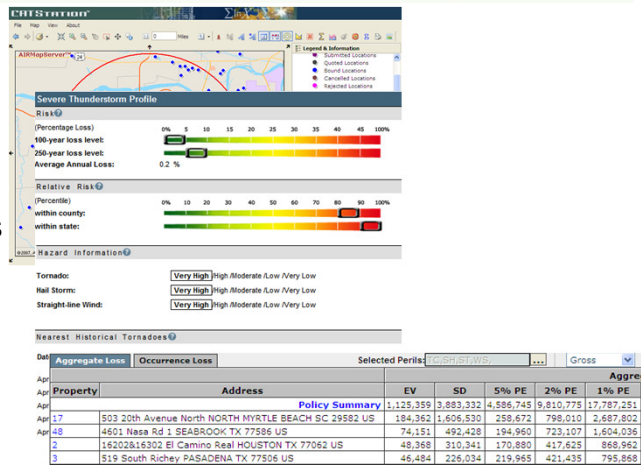


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AIR's Solutions Overcome Limitations of Historical Data For Underwriting Severe Storm

- Exposure concentration analysis
- Hazard analysis
- Loss analysis

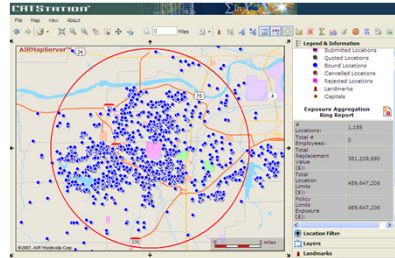


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Actively Manage Exposure Accumulations for Severe Storm

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

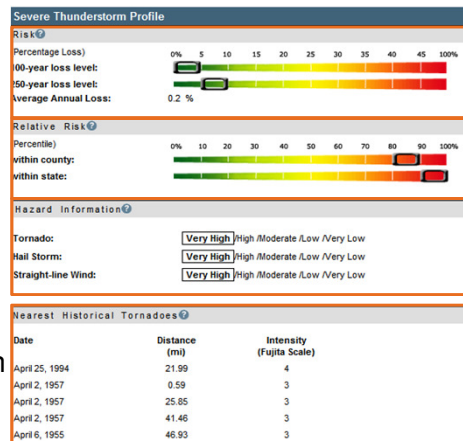


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Hazard Profiles Provide Invaluable Information to Help Manage Severe Storm Risk

- 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



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Modeled Loss Estimates Provide the Best Measure of the Severe Storm Loss Potential for an Account or Location

Hurricane

Aggregate Loss		Occurrence Loss		Selected Perils: TC,SH,...		Gross		Aggre	
Property	Address	EV	SD	5% PE	2% PE	1% PE			
		Policy Summary	920,842	3,815,019	4,099,609	8,989,324	17,214,582		
17	503 20th Avenue North NORTH MYRTLE BEACH SC 29582 US	162,066	1,595,064	228,261	715,857	2,637,079			
48	4601 Nasa Rd 1 SEABROOK TX 77586 US	69,367	485,876	181,245	692,960	1,573,449			
2	16202&16302 El Camino Real HOUSTON TX 77062 US	40,654	267,938	157,575	377,526	749,094			
43	1667 Irish Hill Drive BILOXI MS 39531 US	37,688	257,876	97,766	325,672	824,954			

Hurricane and Severe Storm

Aggregate Loss		Occurrence Loss		Selected Perils: TC,SH,STWS,...		Gross		Aggre	
Property	Address	EV	SD	5% PE	2% PE	1% PE			
		Policy Summary	1,125,359	3,883,332	4,586,745	9,810,775	17,787,251		
17	503 20th Avenue North NORTH MYRTLE BEACH SC 29582 US	184,362	1,606,530	258,672	798,010	2,687,802			
48	4601 Nasa Rd 1 SEABROOK TX 77586 US	74,151	492,428	194,960	723,107	1,604,036			
2	16202&16302 El Camino Real HOUSTON TX 77062 US	48,368	310,341	170,880	417,625	868,962			
3	519 South Richey PASADENA TX 77506 US	46,484	226,034	219,965	421,435	795,868			

Losses would be underestimated by approximately 20% by excluding the peril of severe storm



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Sound Ratemaking for Non-Hurricane Catastrophe Losses Requires a Method to Account for Severe Storm Losses

- Severe storm losses can be substantial and must be explicitly accounted for in rates
- In order to avoid shifts in loss costs caused by volatility in loss experience data, “expected” non-hurricane cat losses should be used in place of actual non-hurricane cat losses experienced over a short time period
 - Commonly done by developing a non-hurricane cat factor
 - Non-hurricane cat 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



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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 + ...



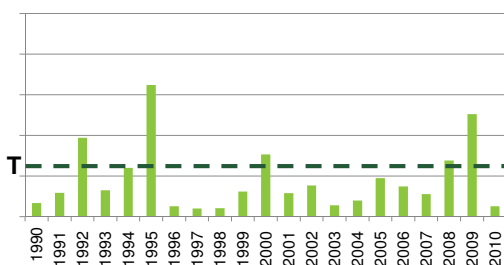
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Next Evolution Is to Blend Actual Loss Experience and Catastrophe Modeling Output

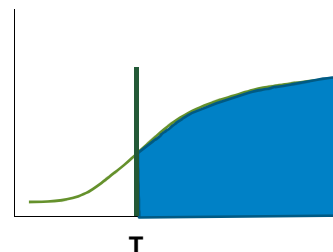
- Use loss experience for catastrophe losses up to a threshold (T) size
- Use modeled loss factor above this threshold
- Rate = Non Cat + (Experience based Cat Load | < T) + (Model Cat Load | > T) + ...

Hypothetical Severe Thunderstorm Losses



Actual Trended Loss Experience

Exceedance Probability Curve



Modeled Loss Potential

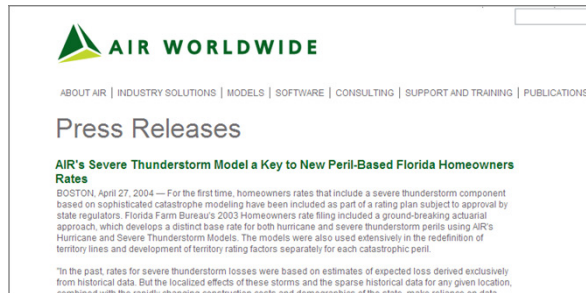


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Using Severe Storm Models in CLASIC/2™ to Support Ratemaking

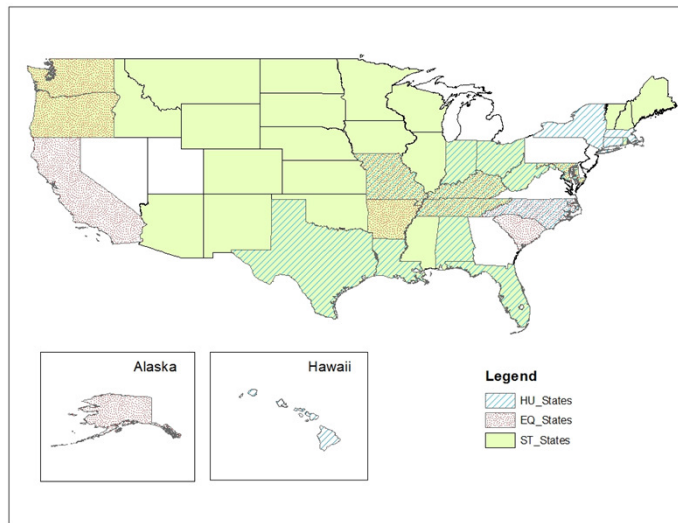
- AIR recommends working with a combination of modeled and actual loss data to establish rates
- Modeled events generally align with PCS catastrophe definition of generating \$25M or greater in industry loss
- AIR supports clients in rate filings using AIR severe storm models



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

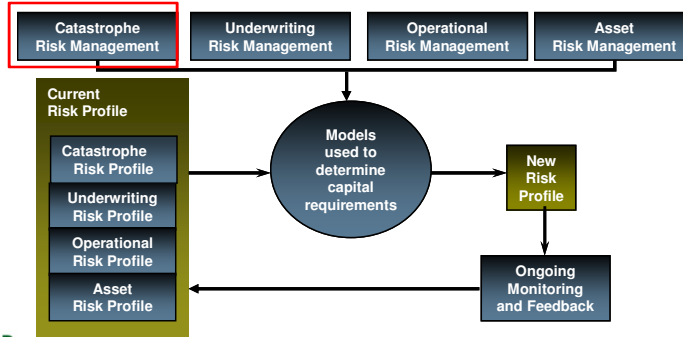


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Catastrophe Risk Is Central to Robust Enterprise Risk Management

- “A framework for mapping (identifying), measuring, monitoring, and managing a wide variety of risks, both independently and in combination” – *AIRCcurrents July 2007*
 - Catastrophe risk is one of the greatest threats to solvency
 - Catastrophe risk highly correlated to operational and asset disruptions
 - Catastrophe losses contribute to earnings volatility



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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?

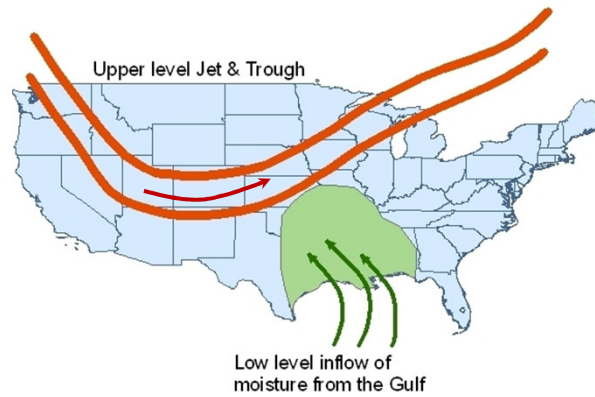


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Key Ingredients for Development and Evolution of Severe Thunderstorms and Tornadoes Are Known

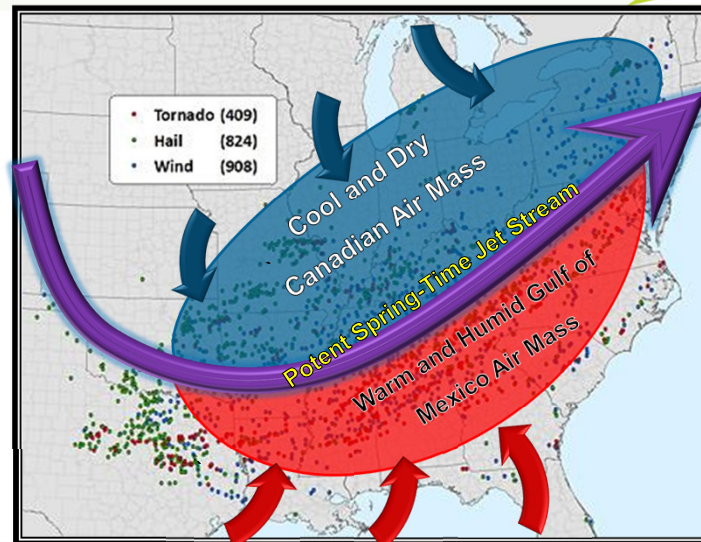
- Upper level jet stream intensity
- Low level inflow of moisture from the Gulf



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



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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 MexicoBoth 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 instabilityThis 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

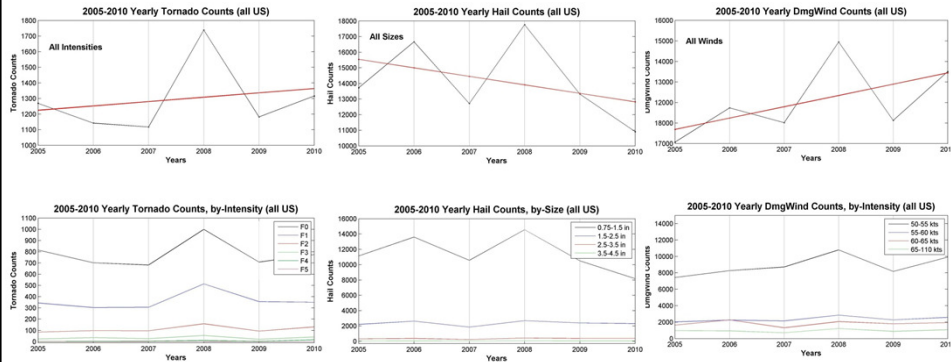


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No Clear Signals Exist to Indicate a Climatological Influence on Severe Thunderstorm Activity for this Period

2005-2010



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Losses Are Increasing Over Time Due to Factors Other than Climate Change

- Severe storm activity in recent years has included multiple storms that affected urban areas
- Increasing exposure values in those urban and suburban areas
- Increasing population in formerly rural areas

"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

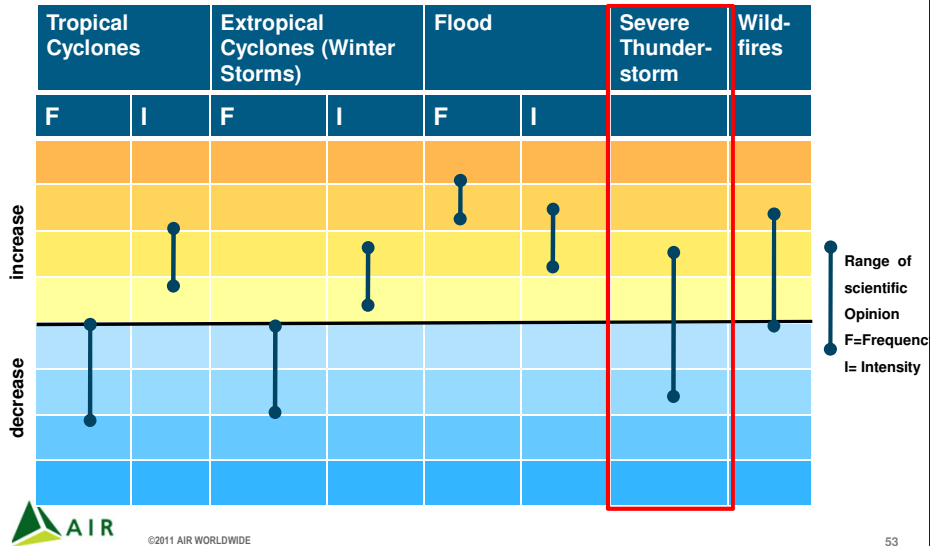
<http://abcnews.go.com/US/tornadoes-strike-city-deadly-rural-twisters/story?id=13746259>



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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