PL-2: Severe Weather Ratemaking

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Casualty Actuarial Society, 2012 Ratemaking & Product Management Seminar

March 19-21, 2012

Philadelphia, PA

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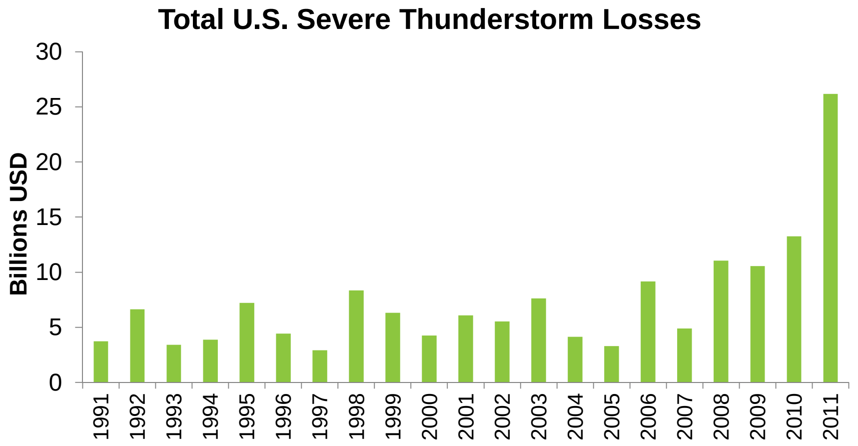
Agenda

- 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

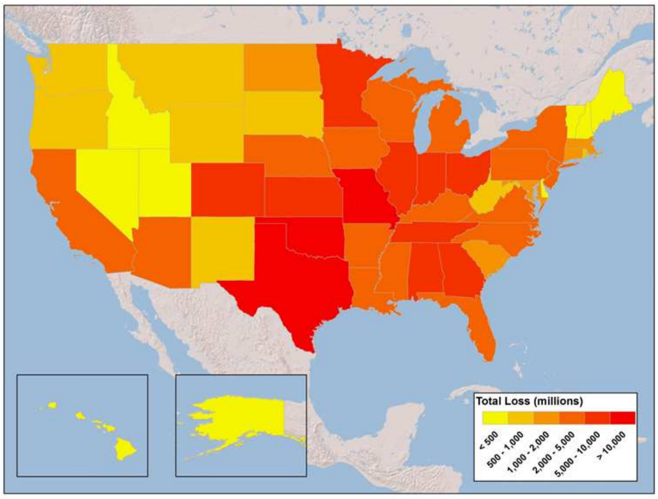
Insured Losses from Severe Thunderstorms, 1991-2011



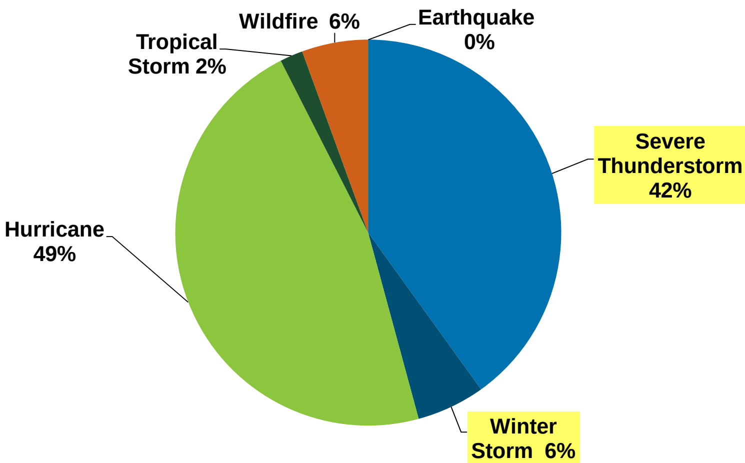
Source: PCS, trended to 2012

All 48 Contiguous States Are Affected by Severe Storms

PCS Losses, 1990-2011, Trended to 2012 Dollars



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



Source: PCS, trended to 2012

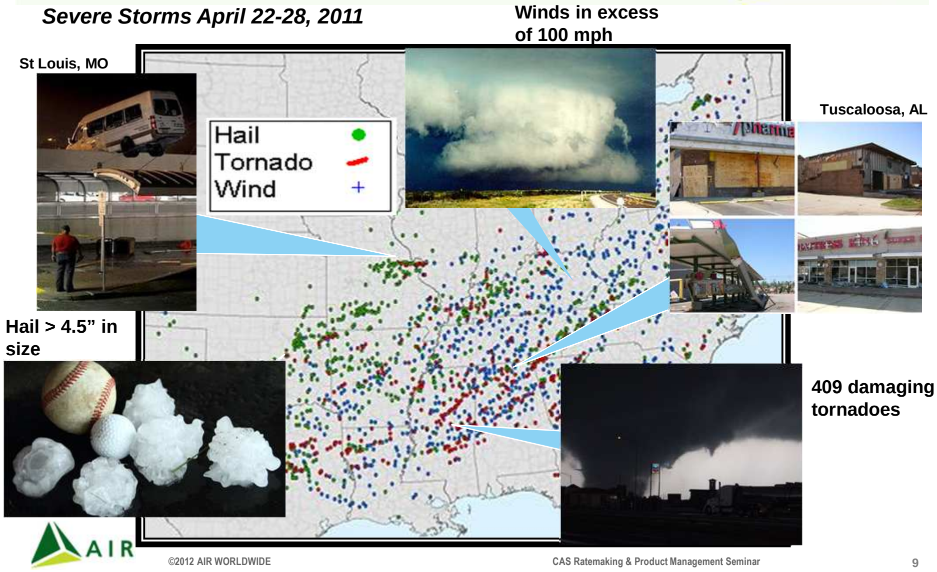
Severe Thunderstorms Can Generate Hail, Tornadoes, and Extreme Straight-line Winds

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

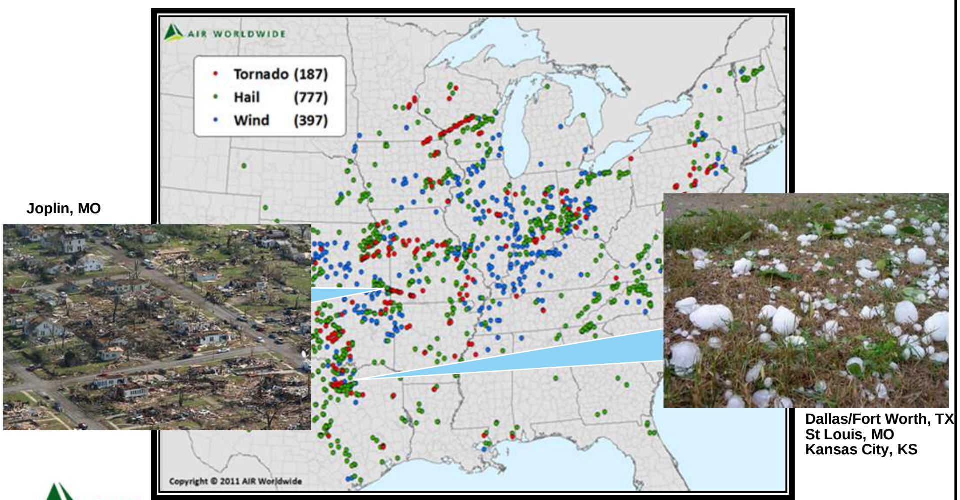
Severe Storms Produce Damaging Tornadoes, Winds, and Precipitation

Severe Storms April 22-28, 2011



Over Seven Days in May 2011, More Than 150 Confirmed Tornadoes Raged Across the Heart of the Country

Severe Storms May 20-27, 2011



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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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 F-Scale, not the other way around
- Damage indicators have been better calibrated in enhanced scale

F0 – F1

Minimal to Moderate Damage
(Roofs peeled off)

F2 – F3

Considerable to Severe Damage
(Roofs and some walls torn off)

F4 – F5

Catastrophic Damage
(Well-constructed structures leveled)

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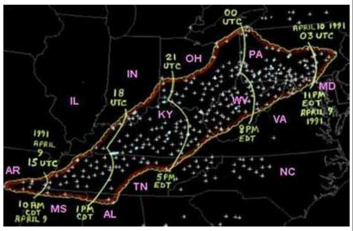
Challenges of Modeling Hail: Intensity and Area

- 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

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

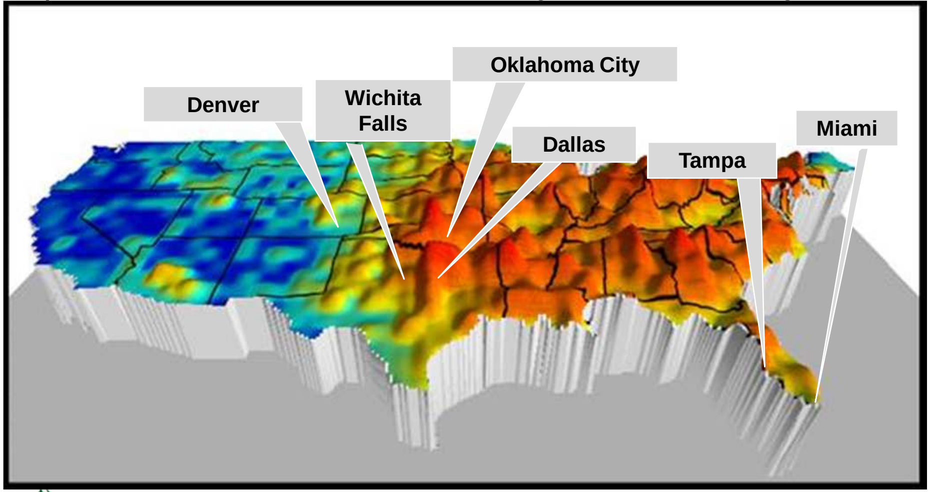


Historical Data From the Severe Thunderstorm Database Are Used to Generate the Model Event Set

- 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 come in separate files and are grouped by AIR into macro events based on geographic distribution and date of occurrence
- More than 2,400 historical macro events have been generated based on these events

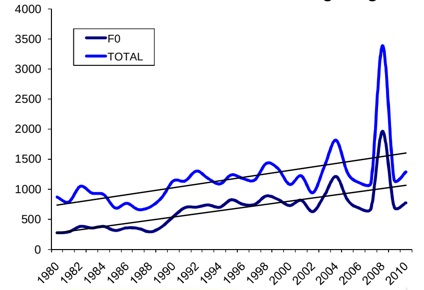
The Distribution of Population Creates Biases in the Reporting of Tornadoes, Hail, and Straight-line Winds

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

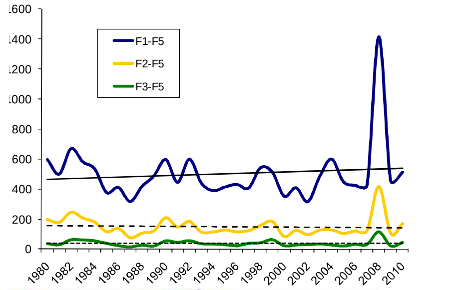


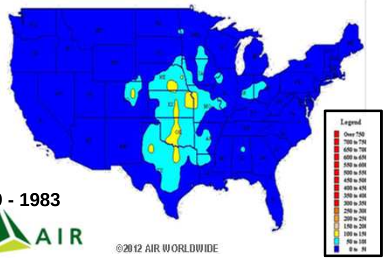
The Historical Data Must be Cleaned to Remove Reporting Biases

Annual Number of Tornado Sightings

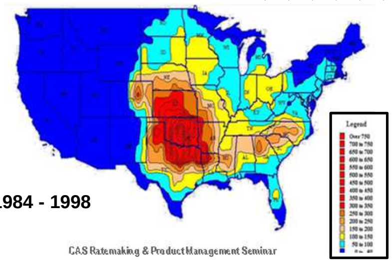


Annual Number of Confirmed Tornado Touchdowns





1969 - 1983



1984 - 1998

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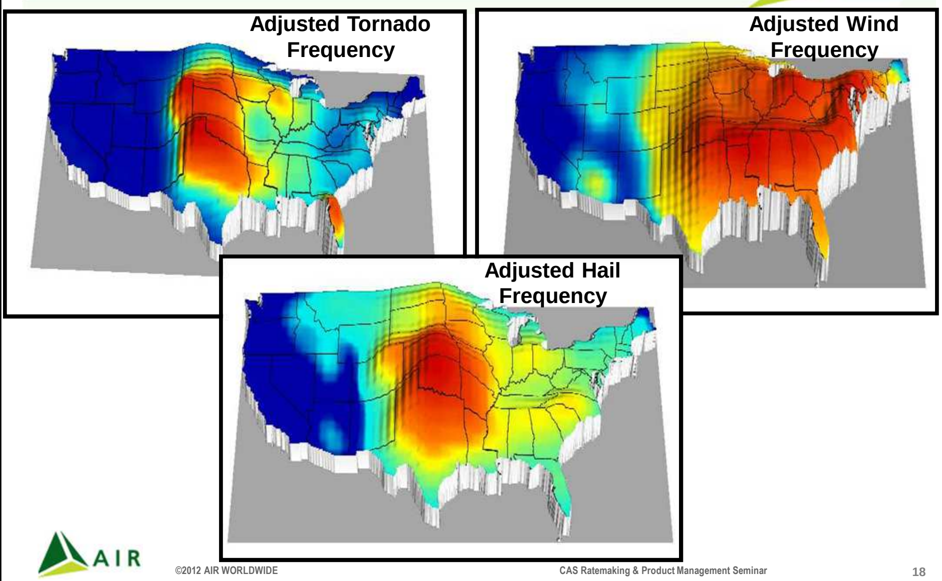
Adjusted Storm Frequencies by Peril Following Data Augmentation and Smoothing



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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

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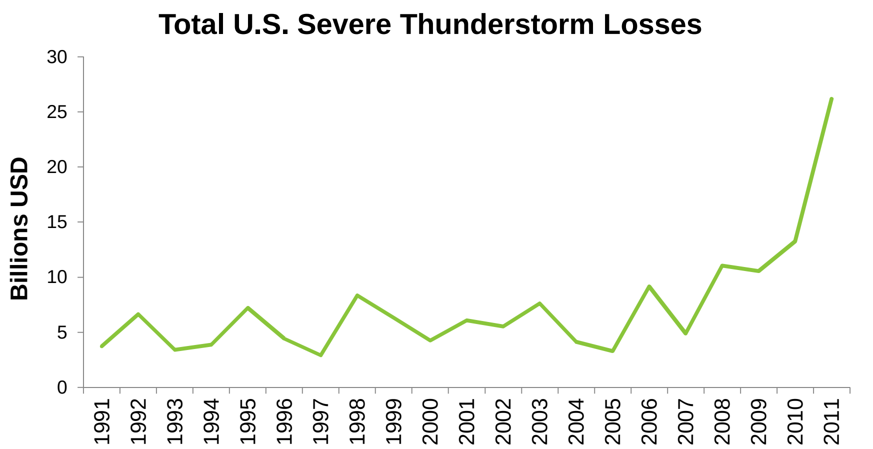
Historical Event Analysis Is Not Sufficient for Managing Severe Storm Risk

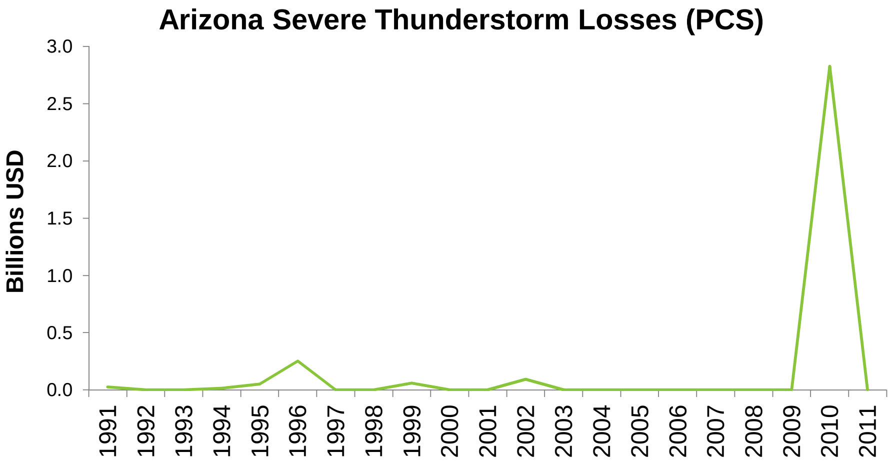
- Volatility of historical loss data
  - Frequency: active vs. inactive periods
  - Severity: minor vs. severe event
- Limited nature of claims data
  - Geographic distribution of historical activity
  - Constantly changing landscape of exposure data
    - New property development
    - Building materials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

Severe Storm Losses Are Volatile from Year to Year



Source: PCS, trended to 2012

Loss Volatility Is Amplified at Higher Levels of Geographic Resolution



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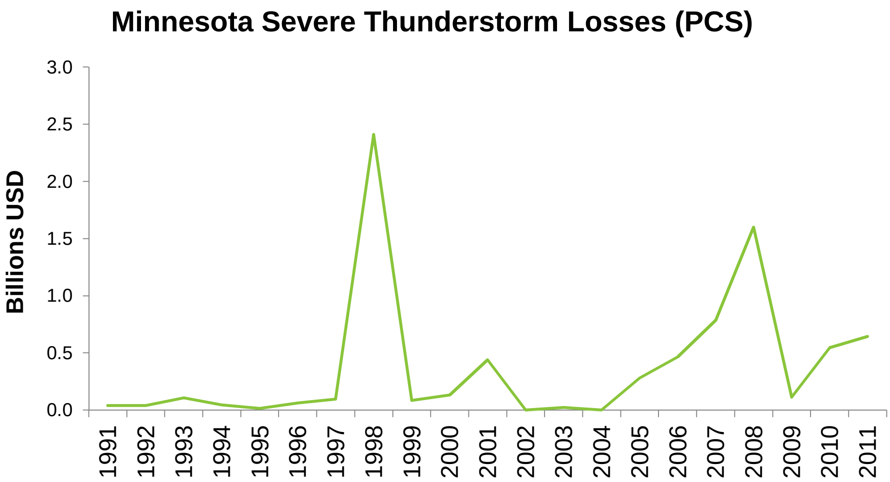


Source: PCS, trended to 2012

Individual Insurers Also Experience Similar Severe Storm Loss Volatility

Example: Insurer Historical Severe Storm Losses

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

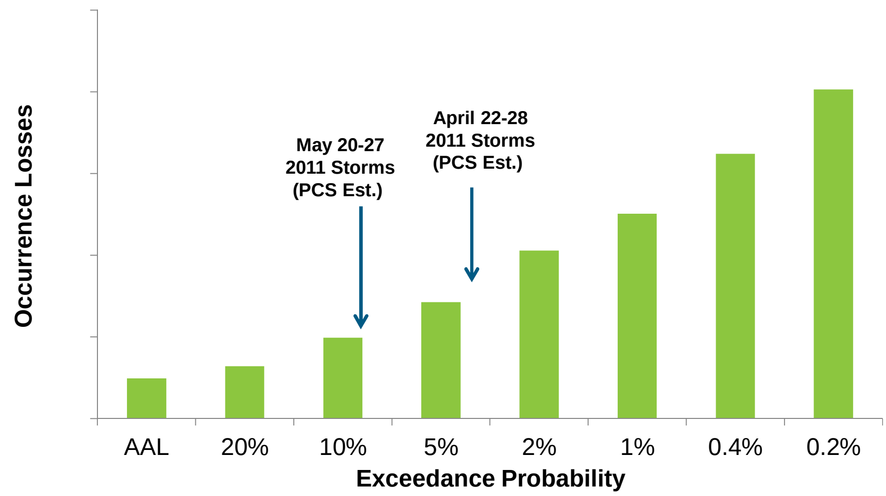
Catastrophe Models Are a Practical Solution to a Widespread Problem

- 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

"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."

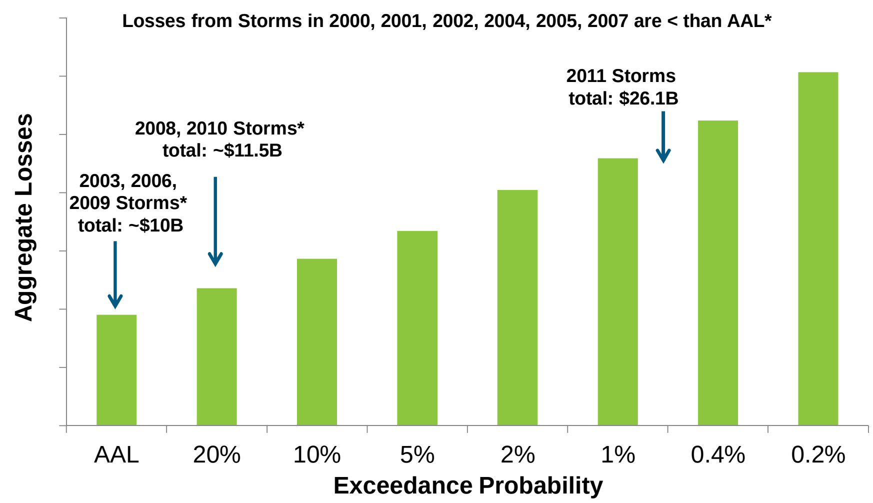
- Prof. Kenneth Blumenfeld, University of Minnesota

Two Significant Clusters of Severe Thunderstorms in 2011



* Trended to Present Dollars

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



* Trended to Present Dollars

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

	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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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

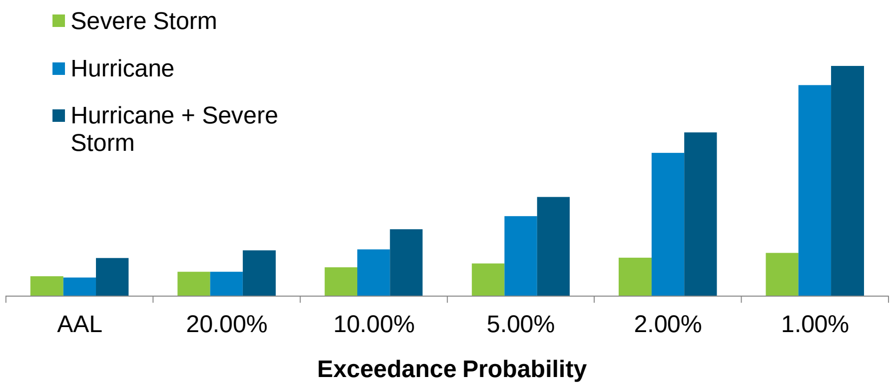
Year 6753	$1.226B
$400M	Florida Hurricane
$363M	Texas Severe Thunderstorm
$332M	Florida Hurricane
$23M	Midwest Severe Thunderstorm
$12M	California Wildfire

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

Comparison of Severe Storm Losses to Hurricane Losses

U.S. Industry Summary EP Curve

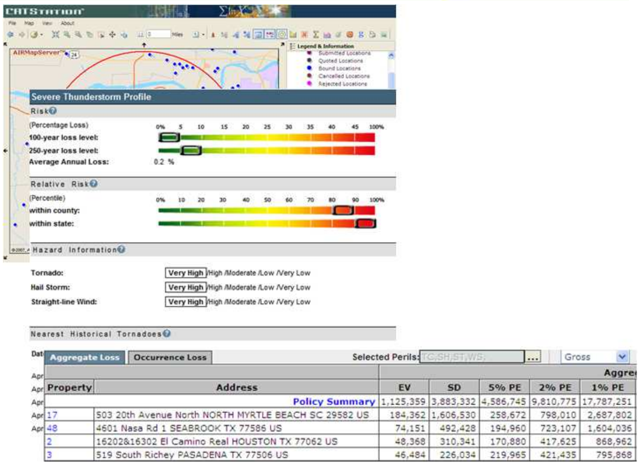


Functional Areas in Which Modeling Severe Storm Losses Can Add Value for Insurers

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

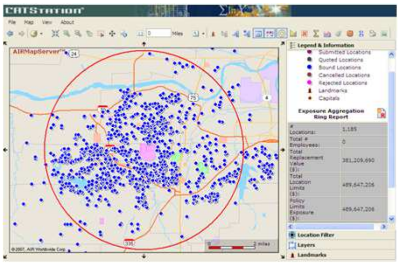
AIR's Solutions Overcome Limitations of Historical Data For Underwriting Severe Storm

- Exposure concentration analysis
- Hazard analysis
- Loss analysis



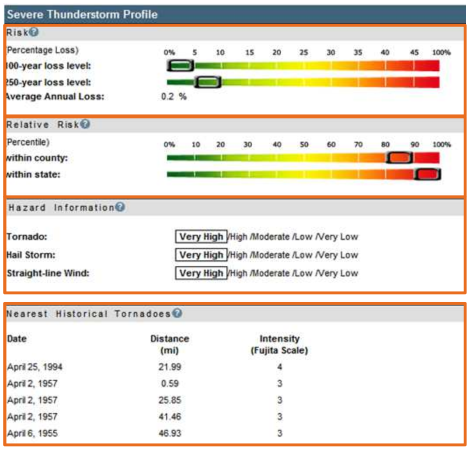
Actively Manage Exposure Accumulations for Severe Storm

- 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.



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



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

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,ST,WS, — Gross

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

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

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

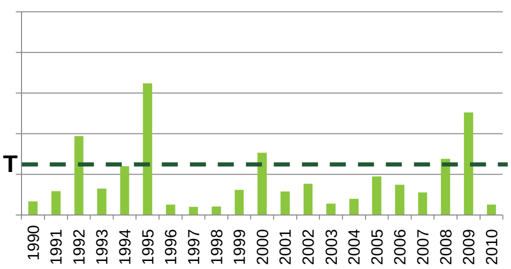
ZIP CODE	AVG LOSS
67855	26,545
67953	8,600
67951	1,650
67954	9,700
67838	4,355
67846	1,247
67880	18,562
67952	10,476
67950	5,754

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

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

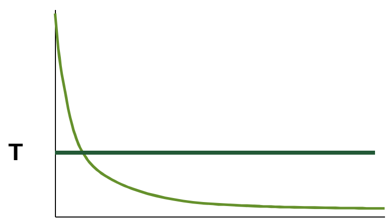
- Use loss experience for catastrophe losses up to a threshold (T) size
- Use modeled loss factor above this threshold
- Rate = Non Cat + (Experience based Cat Load | < T)
  + (Model Cat Load | >T) + …

Hypothetical Severe Thunderstorm Losses



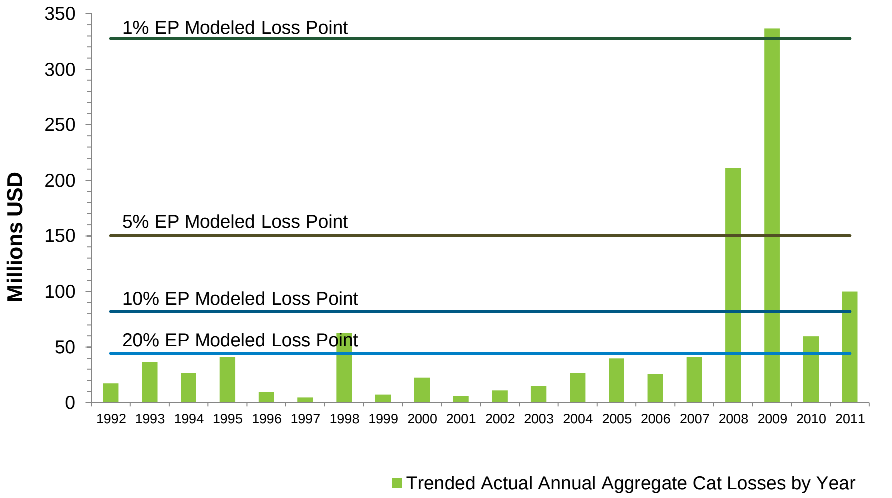
Actual Trended Loss Experience

Exceedance Probability Curve



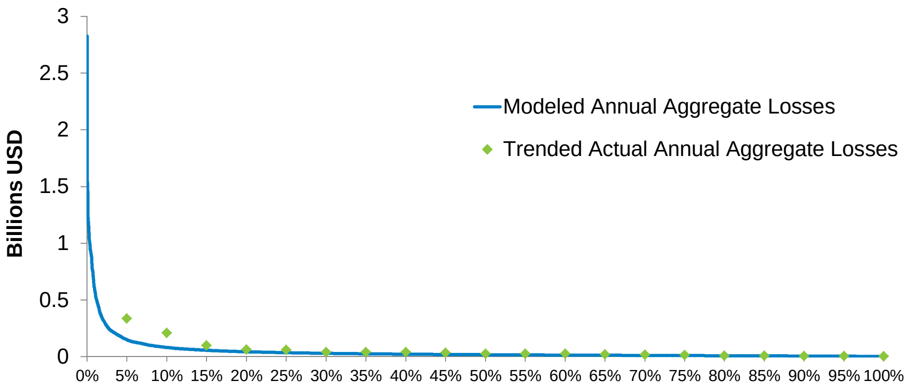
Modeled Loss Potential

Georgia Company Example: Annual Aggregate Catastrophe Claims By Year



*Company data includes Georgia exposures only

Georgia Company Example: Exceedance Probability Curve with Modeled and Actual Losses



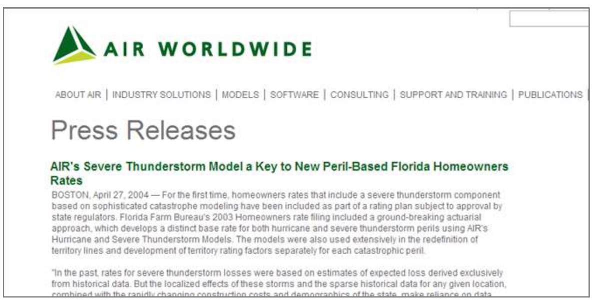
*Company data includes Georgia exposures only

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

Scenario	Earned House Years (000's)	Non-Cat AAL ($M)	Catastrophe Loss Threshold ($M)	Non-Cat Loss Cost (AAL/EHY)	Experience-Based Catastrophe Loss Cost (AAL/EHY)	Modeled Catastrophe Loss Cost (AAL/EHY)	Total Loss Cost (AAL/EHY)
Actual Cat Losses Only	330	150	N/A	454.55	166.65	0.00	621.20
Excl. Losses > 2% EP Point	330	150	327.7	454.55	165.29	21.73	641.57
Excl. Losses > 5% EP Point	330	150	150.3	454.55	129.21	38.43	622.18
Excl. Losses > 10% EP Point	330	150	81.9	454.55	105.76	52.94	613.25
Excl. Losses > 20% EP Point	330	150	44.1	454.55	83.40	68.88	606.83
Modeled Losses Only	330	150	0.0	454.55	0.0	136.66	591.21

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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Press Releases

AIR's Severe Thunderstorm Model a Key to New Peril-Based Florida Homeowners Rates

BOSTON, April 27, 2004 — For the first time, homeowners rates that include a severe thunderstorm component based on sophisticated catastrophe modeling have been included as part of a rating plan subject to approval by state regulators. Florida Farm Bureau's 2003 Homeowners rate filing included a ground-breaking actuarial approach, which develops a distinct base rate for both hurricane and severe thunderstorm perils using AIR's Hurricane and Severe Thunderstorm Models. The models were also used extensively in the redefinition of territory lines and development of territory rating factors separately for each catastrophic peril.

"In the past, rates for severe thunderstorm losses were based on estimates of expected loss derived exclusively from historical data. But the localized effects of these storms and the sparse historical data for any given location, combined with the rapidly changing construction costs and demographics of the state, make reliance on data

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

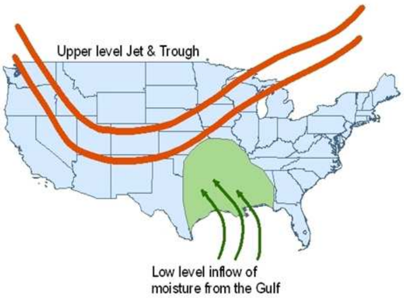
Questions of Concern to Many U.S. Insurers

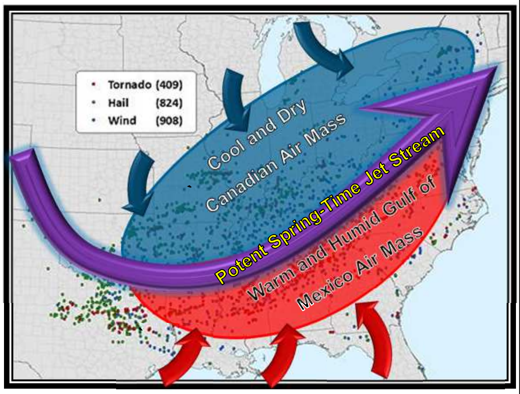
- Is U.S. severe thunderstorm risk increasing?
- What is the impact of climate change on severe thunderstorm risk?
  - Is there a detectable signal?
  - Is the underlying data dependable?



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

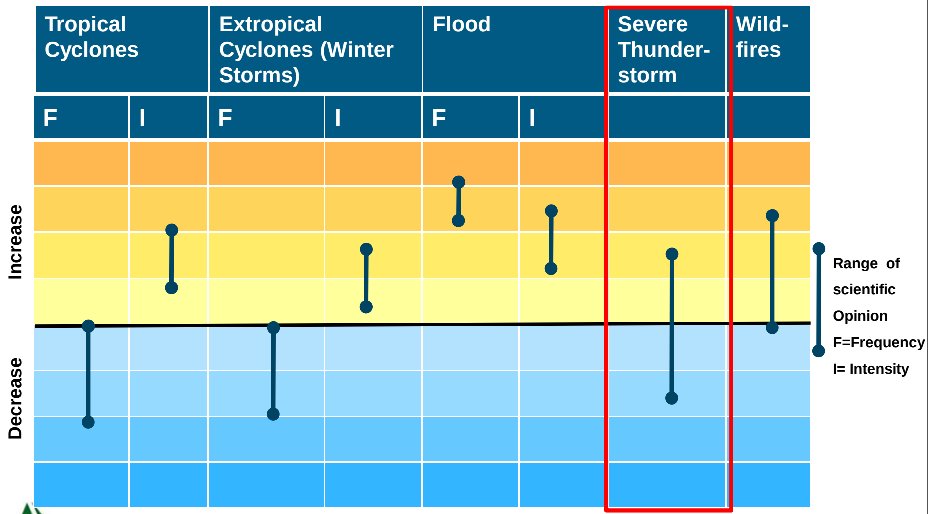
  Both these effects inhibit the occurrence of severe weather
- 2011 featured a weakening La Niña to neutral conditions which led to a meandering jet stream over U.S. This set-up:
  - Numerous cold air outbreaks which interacted with the warm and moist air coming from the south, which in turn resulted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

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 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