# SEVERE CONVECTIVE STORM MODELING

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*Manager, Model Product Management*

# A RECENT SURVEY

What peril concerns you on a day-to-day basis?

In your opinion, what is the biggest threat regarding climate change?

Has your company made changes to your severe weather ratemaking methodology in the last 3 years?

# A RECENT SURVEY

#1: SCS
#2: Flood
#3: Hurricane

SCS, Flood, and Storm Surge/ Hurricane

~80% yes!

# RISK OVERVIEW

## Loss

Accounts for 1/3 of all US peril AAL (~11 billion USD)

## Historical Losses

Several events in last 15 years exceed $2 billion in loss

- 3 events in 2011
- 2 so far in 2013

## Risk

High risk to aggregate covers, auto lines, and large single location risks

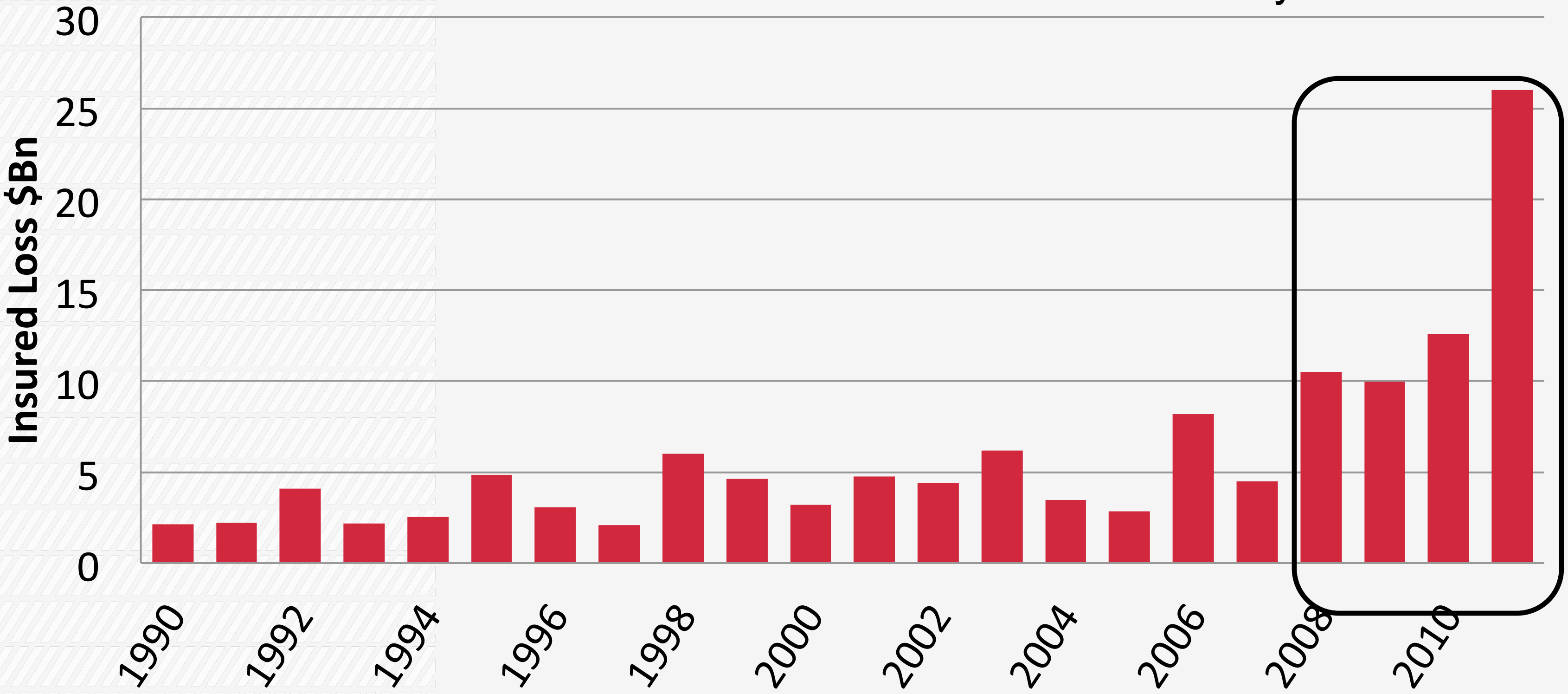
Eats at profit, as most risk is retained

## Challenges

Event frequency not well captured in statistical data

SCS annual losses can be volatile/ non-stable

SCS Activity Since 1990




Source: PCS

# OUTLINE

- Intro to the RMS Severe Convective Storm model
- Applications and considerations
- Resilient risk management

# SEVERE CONVECTIVE STORM MODELING

# FOUR PERILS OF SEVERE CONVECTIVE STORMS

- Hail
  - Most frequent of SCS perils
  - Auto and Residential lines most at risk
  - Smaller damage ratios, over large areas
- Tornadoes
  - Rarest of the SCS perils
  - Highest damage ratios
- Straight-line winds
  - Largest footprints of SCS perils
  - Treefall an issue for residential and auto
- Lightning
  - Frequent, but least damaging
  - Losses to electrical equipment (power surge)


# FRAMEWORK FOR SCS MODELING

Generate Events

Assess Hazard

Calculate Damage

Quantify Financial Loss

# EVENT GENERATION

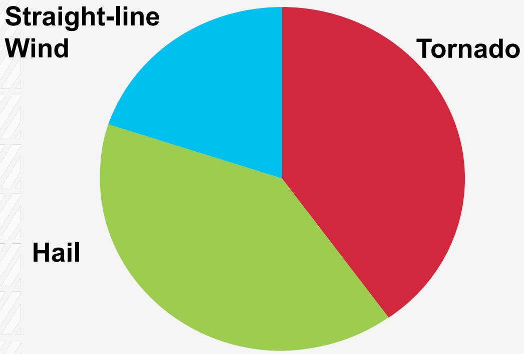
# CHALLENGE: DEFINE THE PERIL

Image via foldedstory.com

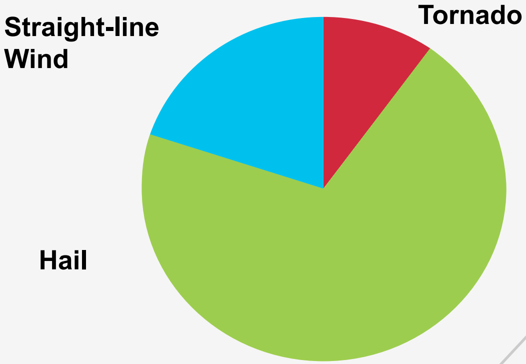
# CHALLENGE: DEFINE THE PERIL

- Tornadoes are #1 driver for loss of life
  - 324 deaths in April 2011 outbreak
  - Last death due to hail in US was 12 years ago; ~1,000 deaths due to tornadoes in same period
- Hail storms are #1 driver for insurance loss
  - Aggregate loss: hail is dominant, 60% of all claims
  - Tail loss: hail & tornado are ≈ 40%

**Large Event Losses**




**Annual Losses**

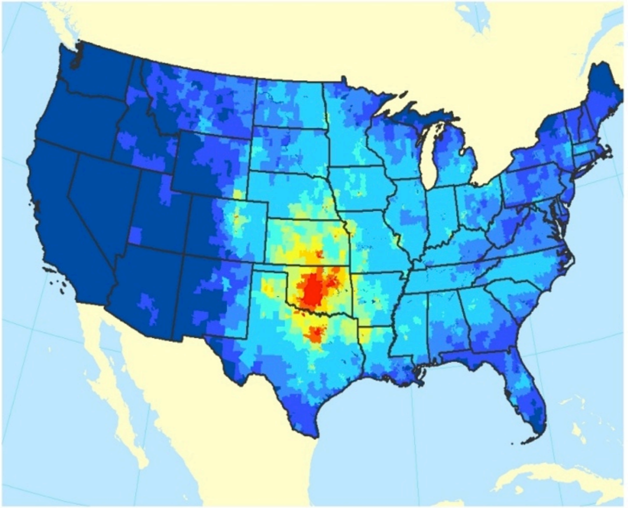


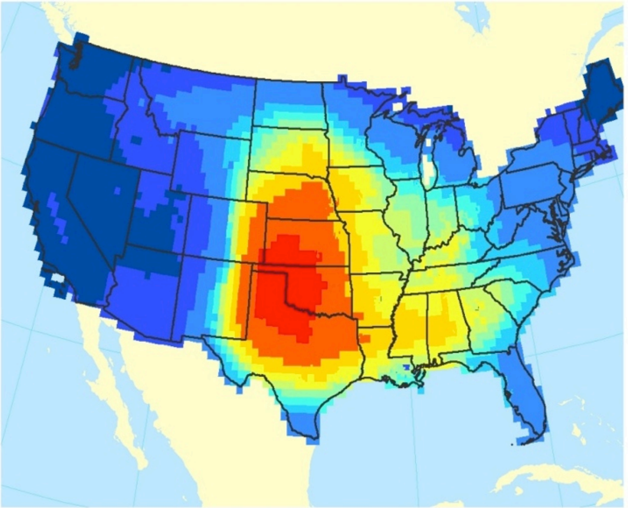

**Based on Claims Data**

# CHALLENGE: BIASED HISTORICAL RECORDS

***Records and Observations (PCS)*** are limited to and biased by observation location and damage.

***Cat Models*** can provide physically-based frequency and severity distributions with complete coverage.





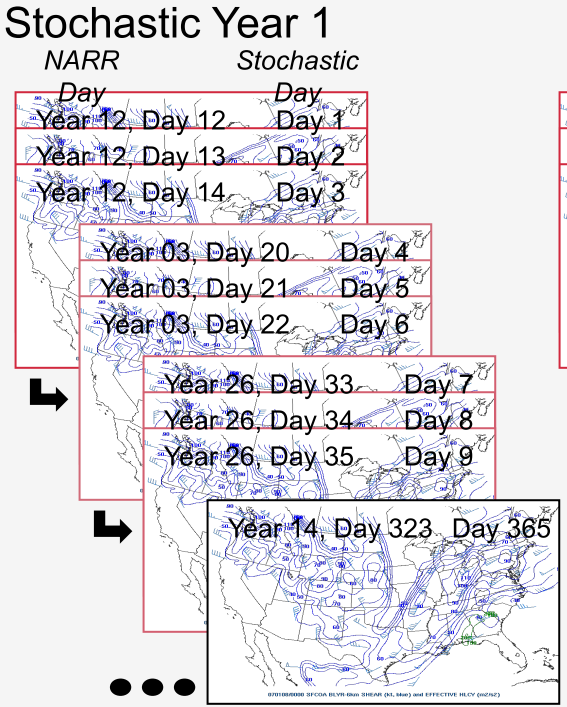
Low ⟷ High

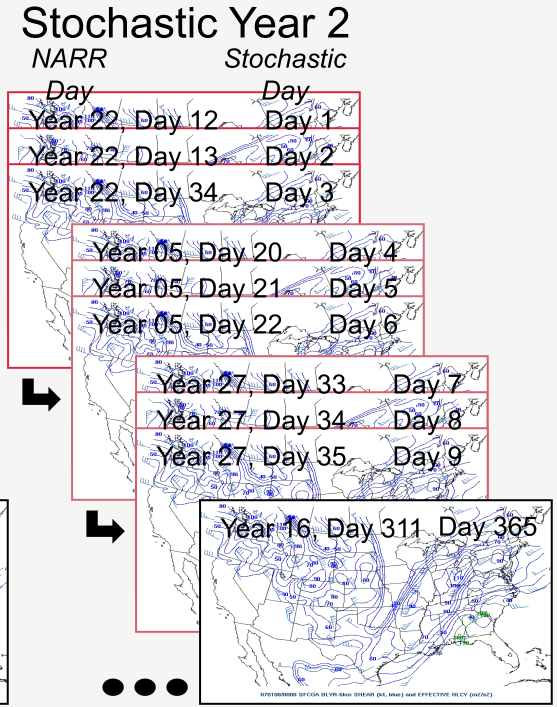
Hazard

# SCS EVENT GENERATION

**Simulate stochastic years of atmospheric conditions**

- Resample events from the North American Regional Reanalysis (NARR)
  - Reanalysis data from 1979-2005
- Create “stochastic” years
  - 3-day blocks within 3 month periods
  - Over 27 years of data
  - Preserve seasonality
  - Preserve temporal and spatial correlations

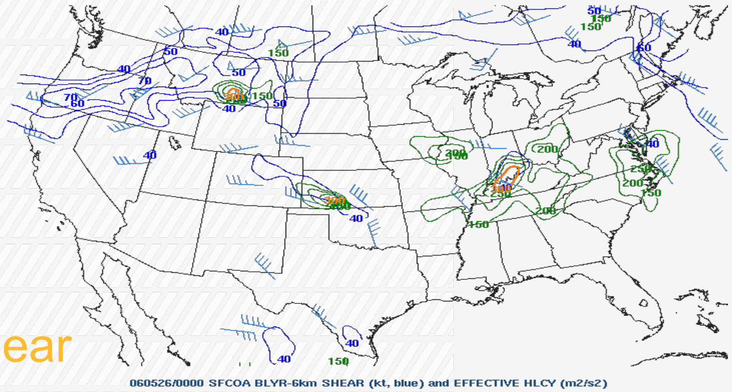


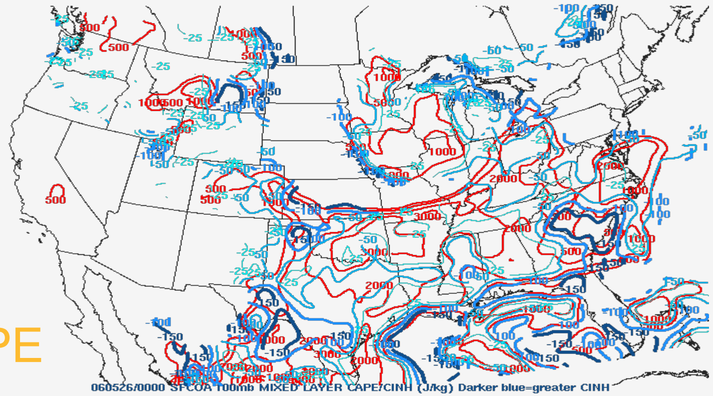
# SCS EVENT GENERATION: PUTTING IT ALL TOGETHER

**A hybrid model that unites statistics with numerical modeling**

- Numerical modeling provides thousands of years of large-scale, 3D meteorological “ingredients” for storms
- Statistics are used to place tornado, hail, and straight-line winds in each cell using probability distributions and historical data
- Result is verified and calibrated against historical observations and damage surveys where appropriate




Shear




CAPE

# CHALLENGE: HIGH-FREQUENCY EVENTS

| State | % AAL HF |
|---|---|
| Alabama | 9% |
| Oklahoma | 10% |
| Texas | 14% |
| Louisiana | 16% |
| Wyoming | 24% |
| New York | 28% |
| Massachusetts | 45% |
| Nevada | 77% |
| Washington | 82% |

2011 IED, All Lines,
All Subperils

- High-frequency events can contribute over 50% of the annual AAL in some regions, particularly in the West
- Impractical to model as individual events
- SCS model's solution:
  - Determine percentage of claims from high-frequency events, verify with CAPE as proxy for thunderstorms
  - 1 pseudo-event per state
  - Model as an annual occurrence (frequency = 1) for the aggregate contribution of high-frequency events to the location AAL



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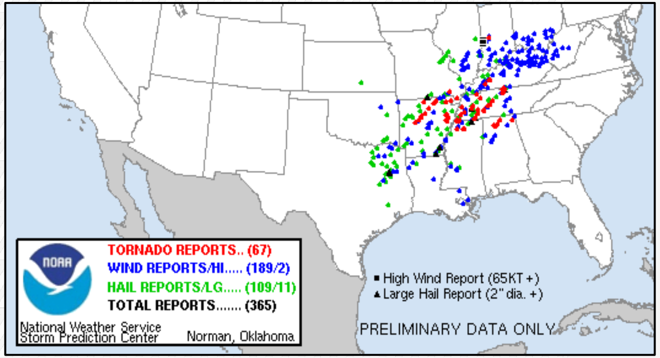
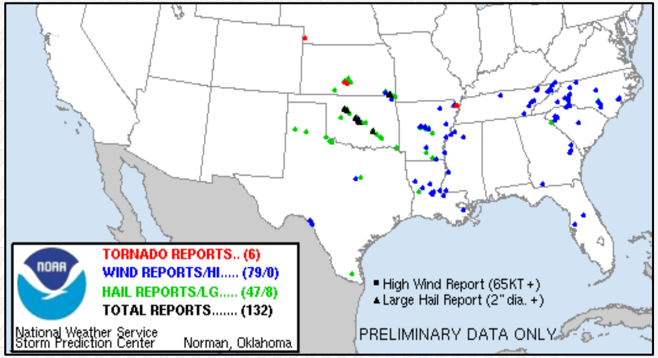
# CHALLENGE: HIGH-FREQUENCY EVENTS

Low-frequency event: Major severe weather outbreak



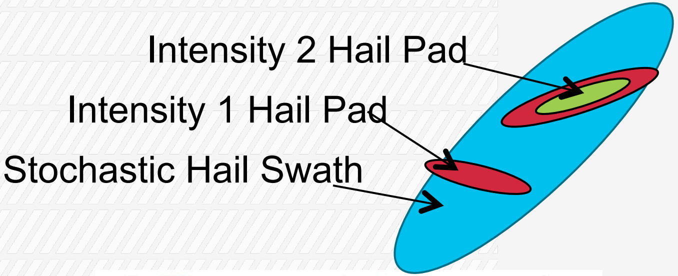

High-frequency event: Isolated t-storms/wind

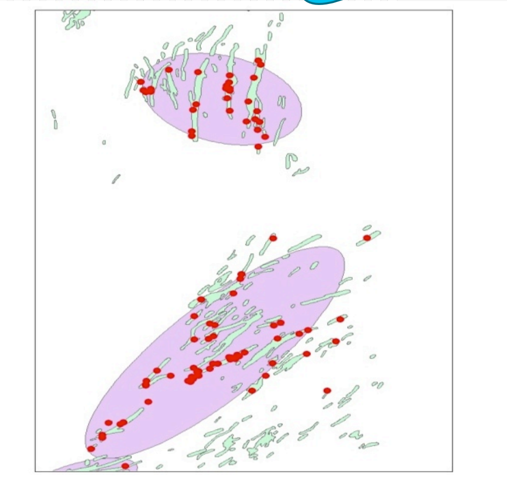



| | Low-Frequency Events | High-Frequency Events |
|---|---|---|
| Storm Type | Cat events | Non-Cat events |
| Examples | Thunderstorms<br>Straight-line winds<br>Tornadoes<br>Lightning | Isolated Thunderstorms<br>Downbursts<br>Hailstorms |
| Storm size | Large-scale (1000s of sq mi or km) | Small-scale (10s of sq mi or km) |
| RiskLink Stochastic footprint? | Yes | No |
| Regional Impact | Dominant in Midwestern Plains | Dominant in West |

# HAZARD

# HAIL



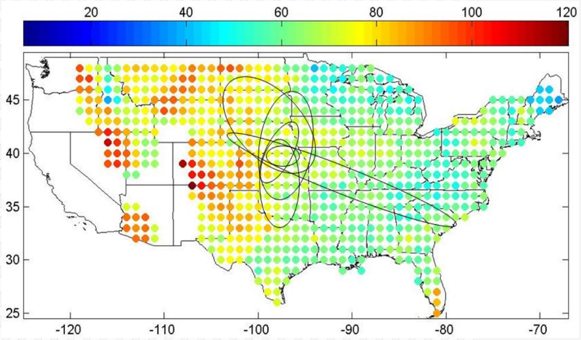



*Ellipses fitted to the SPC points for the event of 3 May 1999, along with the WDT polygons from radar.*

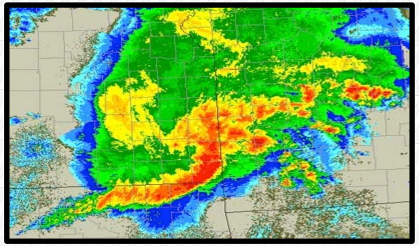
- Hailstorms
  - Many hail swaths per day possible
  - Calibrated with 50 years of observations
- Hail swaths often occur in clusters
  - Modeled at two intensity levels
  - Intensity related to hail stone size and density
  - Intensity distribution varies geographically
  - Number of hail swaths, size, and intensity distribution dependent on storm size
  - Footprint morphology calibrated on historical and radar data

# STRAIGHT-LINE WINDS

Wind Surface Grid

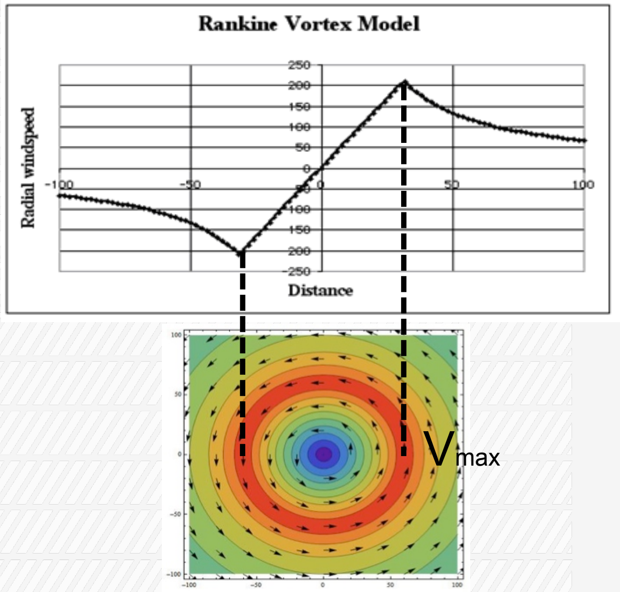



MPH



- Ranging from microburst to derecho (1 mn/yr vs. 25 year)
- Derecho – widespread, long-lived convective windstorm
- Size: 3 miles to 100+ miles wide
- Duration: minutes to 24 hr
- Wind speeds: up to 100 mph gust
- Methods of reconstructing straight-line winds
  - Storm Prediction Center historical reports
  - Airport locations, mesonet stations, Global Summary of the Day
  - Examine roughness

# TORNADO

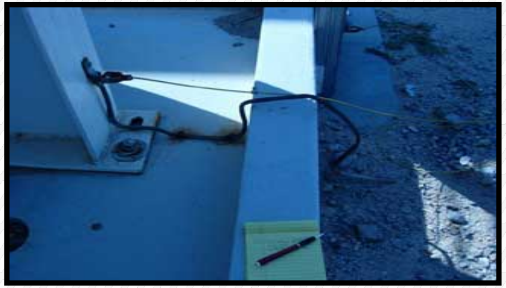



*Tornado intensity based on Rankine vortex model.*

- Outbreak modeled by maximum F-intensity tornado
- Historical tornado reports are clustered into larger outbreaks (similar to hail)
- Intensity size distributions based on Rankine vortex model
- Adjusted with high-resolution damage surveys (from scientific literature, consultants)

*Goshen County WY: June 5th, 2009*

# LIGHTNING



- Losses from lightning strikes (non-fire)
- Two main damage modes:
  - Damage at point of entry (singe or burn marks)
  - Electrical system (electronics that are plugged in)
- Typically low damage ratios
- Highly correlated with hail hazard so modeled on top

# VULNERABILITY

# PERIL-SPECIFIC VULNERABILITY FUNCTIONS

*Photos from RMS (Matthew Nielsen)*

- Distinct functions for Hail, Tornado, and Wind
- Hail → kinetic energy
  - Key vulnerability components:
    - General roof shape (e.g. steep, low slope)
    - Roof cover (e.g. asphalt, shake, tile, built-up, single-ply)
    - Roof age (critical age ~10-15 years for most types)
- Tornado → F-rating
  - Relates damage to approximate wind speed range
- Straight-line winds → peak gust
  - Dominant range of wind speeds < 80 mph
  - Tree damage
- Use of claims data and consultants for calibration/validation

# FUTURE MODEL UPDATES: RISKLINK

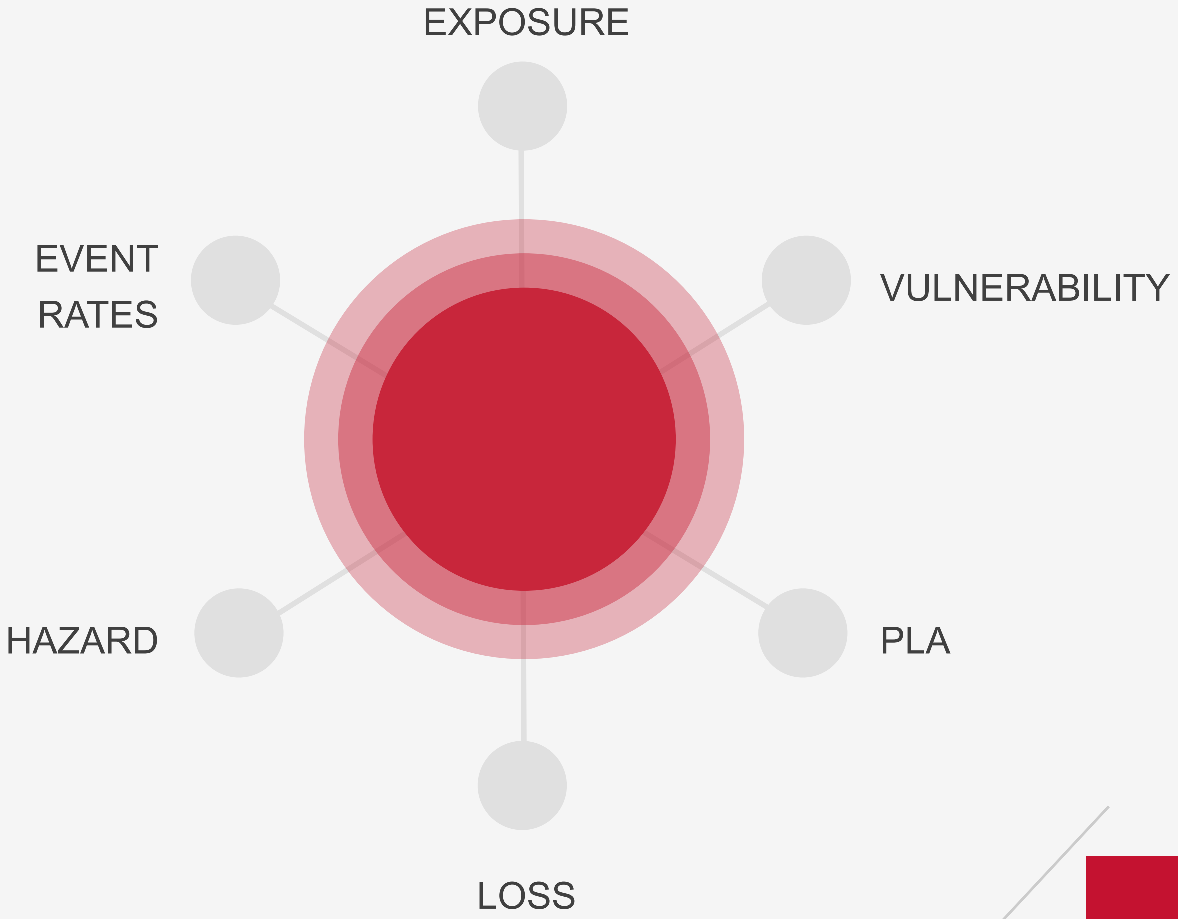
- Interim update of SCS model in January 2014
- Fundamentals of event generation module still strong
- 2008-2012 taught us new lessons that we wish to integrate
  - Add information on tail events and EPs from 2008-2012 SCS seasons
  - Integrate new client data to further refine hazard and vulnerability

# FUTURE MODEL UPDATES: RMS(ONE)

Spring 2014: SCS translated for use on RMS(one)

More powerful platform to make the model work for you:

- Conduct sensitivity tests
- Leverage your own claims data and research
- Gain competitive advantage

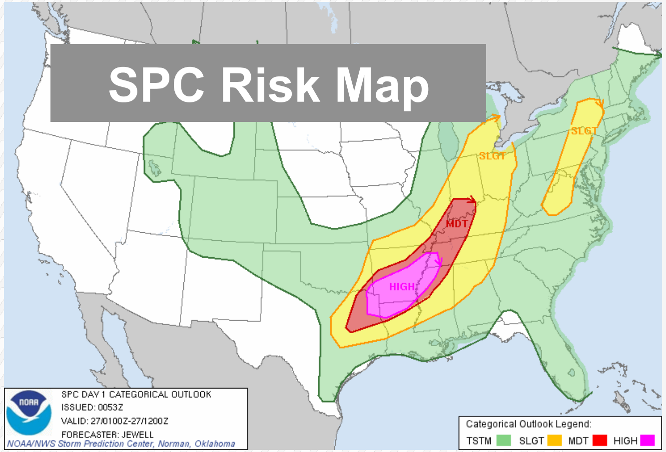


# SCS APPLICATIONS & CONSIDERATIONS

# IMPLICATIONS AND APPLICATIONS

- Ratemaking (primary companies)
  - Statewide level
  - Territorial
  - Class Plans
  - Policy Terms
- Transfer of Risk (e.g., reinsurance)
- Concentration of Risk

# HOW EVENTS ARE DEFINED




- Any vertically developed thunderstorm that produces damage due to hail, tornado, and/or a straight-line wind
- Can occur in all states and provinces in the U.S. and Canada any time during the year
- Peril model and catastrophe model
- Event can be
  - Synoptic* system
  - Used in RiskLink to capture high-frequency losses

***synoptic = large scale atmospheric phenomenon**

# EXPERIENCE DATA

- Low frequency
  - PCS definition
    - >=$25M industrywide, and
    - >=$5M for any state
    - Gross loss
    - Lifetime of synoptic system
  - Company ID
  - ~$Ms
- High frequency
  - Remainder – “follows” low freq
  - One “event” per year for each state
  - $10,000s to $100,000s

# HIGH FREQUENCY AND LOW FREQUENCY SCS LOSSES

| | Contributes to AAL | EP curve | Discrete Events |
|---|---|---|---|
| Low Freq | Yes | AEP / OEP | Yes |
| High Freq | Yes | Becomes meaningful when combined with low-frequency losses | Thousands of actual occurrences every year.<br><br>One event each year per state/province with varying hazard at more granular level. |

# AAL BY PRIMARY CHARACTERISTICS

- Reference Structure: 200k structure, 150k contents, 40k ALE ($250 deductible)
- Selected location in Midwest

| Scenario | Construction | Occupancy | Yr Built | # of Stories | AAL | CV |
|---|---|---|---|---|---|---|
| 1 | Unknown | Unknown | Unknown | Unknown | $82 | 32.7 |
| 2 | Wood | Unknown | Unknown | Unknown | $107 | 27.0 |
| 3 | Wood | SFD | Unknown | Unknown | $123 | 23.6 |
| 4 | Wood | SFD | 1995 | Unknown | $113 | 25.0 |
| 5 | Wood | SFD | 1995 | 2 | $97 | 27.2 |

# AAL BY PRIMARY CHARACTERISTICS

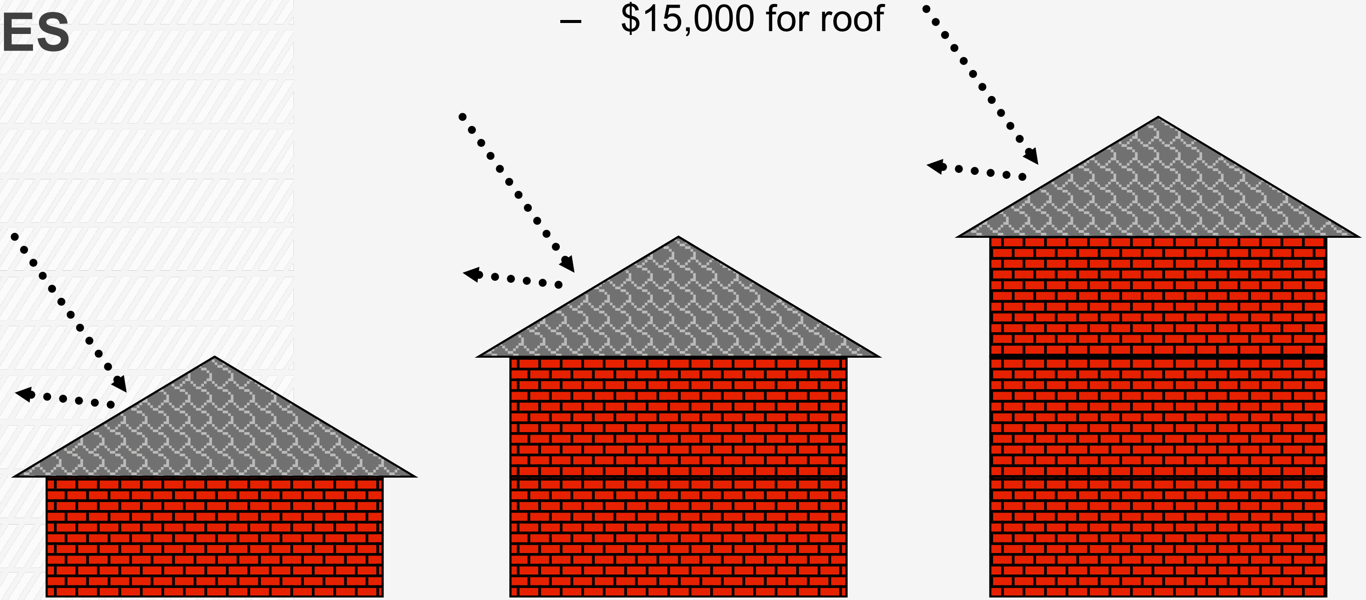
| Scenario | Construction | Occupancy | Yr Built | # of Stories | AAL | CV |
|---|---|---|---|---|---|---|
| 6 | Wood | SFD | 2005 | 2 | $95 | 27.8 |
| 7 | Wood | SFD | 1965 | 2 | $107 | 25.5 |

| Scenario | Construction | Occupancy | Yr Built | # of Stories | AAL | CV |
|---|---|---|---|---|---|---|
| 6 | Wood | SFD | 2005 | 2 | $95 | 27.8 |
| 8 | Wood | SFD | 2005 | 1 | $115 | 24.7 |

## PRIMARY CHARACTERISTICS:
## NUMBER OF STORIES

Risk is primarily determined by the roof system covering and its value relative to the remainder of the structure

- Brick veneer structure example
- $100,000 per story replacement cost
- $15,000 for roof



13% Damage Ratio    7% Damage Ratio    5% Damage Ratio

# SECONDARY MODIFIERS

Secondary modifiers are invoked only when sufficient primary characteristics are known: occupancy, construction class, year of construction, and building height

| Hail | Tornado | Straight-line Wind |
| --- | --- | --- |
| • Roof System Covering<br>• Cladding Type<br>• Roof Age<br>• Mechanical and Electrical Systems | • Foundation System<br>• Roof Anchor<br>• Wind Missiles<br>• Tree Density<br>• Cladding | • Tree Density<br>• Roof System Covering<br>• Roof Sheathing Attachment |

# DEDUCTIBLES

- Given that AAL is driven in large part by hail, damage ratios for SCS tend to be on the smaller side (5-10%)
- These types of loss ratios can be very sensitive to the deductible chosen when modeling SCS

Real-world case study:

- Take a book of business for a particular state, and change the deductible from $250 to 1% of the limit
- Determine the change to AAL and RP losses as a result

| Loss Metric / Return Period | Change |
|---|---|
| AAL | -25% |
| 5 | -20% |
| 10 | -20% |
| 50 | -15% |
| 100 | -15% |
| 250 | -10% |
| 500 | -10% |



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# MAY NEED ADDITIONAL EXPECTED $$

- Included
  - Tree fall
  - Debris removal
  - Power outage if there is direct damage to the location
- Non-modeled losses
  - Flood
  - Fire following
  - Power outage off premises unless there is direct damage to the location
- Can model auto

# MORE INFORMATION

- RMS document in response to ASOP #38: **Using Models Outside the Actuary's Area of Expertise (Property and Casualty)**
- Provides basic understanding of the model
- Non-proprietary – just ask

# THE FUTURE: RESILIENT RISK MANAGEMENT

# RESILIENT RISK MANAGEMENT

| Models aren't perfect | Resiliency in principal | Resiliency in practice |
| --- | --- | --- |
| Catastrophe risk is characterized by deep uncertainty | Understanding implied bets | Diagnostic views and sensitivity tests |
| Learning is ongoing | Adapting quickly to new information | Agile updates, post-event and interim views |
| One size doesn't always fit all | Owning a view of risk | Adjustments, alternatives, open platform |

# BENEFITS OF OWNING YOUR VIEW OF RISK