A RECENT SURVEY

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

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

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

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

~80% yes!

SCS, Flood, and Storm Surge/Hurricane
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
• 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
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%

**CHALLENGE:** DEFINE THE PERIL

**Large Event Losses**
- Hail
- Tornado
- Straight-line Wind

**Annual Losses**
- Hail
- Tornado
- Straight-line Wind

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.
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
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
### CHALLENGE: HIGH-FREQUENCY EVENTS

- 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

<table>
<thead>
<tr>
<th>State</th>
<th>% AAL HF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>9%</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>10%</td>
</tr>
<tr>
<td>Texas</td>
<td>14%</td>
</tr>
<tr>
<td>Louisiana</td>
<td>16%</td>
</tr>
<tr>
<td>Wyoming</td>
<td>24%</td>
</tr>
<tr>
<td>New York</td>
<td>28%</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>45%</td>
</tr>
<tr>
<td>Nevada</td>
<td>77%</td>
</tr>
<tr>
<td>Washington</td>
<td>82%</td>
</tr>
</tbody>
</table>

2011 IED, All Lines, All Subperils
### CHALLENGE: HIGH-FREQUENCY EVENTS

<table>
<thead>
<tr>
<th>Low-Frequency Events</th>
<th>High-Frequency Events</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storm Type</strong></td>
<td><strong>Cat events</strong></td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td>Thunderstorms</td>
</tr>
<tr>
<td></td>
<td>Straight-line winds</td>
</tr>
<tr>
<td></td>
<td>Tornadoes</td>
</tr>
<tr>
<td></td>
<td>Lightning</td>
</tr>
<tr>
<td><strong>Storm size</strong></td>
<td>Large-scale</td>
</tr>
<tr>
<td></td>
<td>(1000s of sq mi or km)</td>
</tr>
<tr>
<td><strong>RiskLink Stochastic footprint?</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Regional Impact</strong></td>
<td>Dominant in</td>
</tr>
<tr>
<td></td>
<td>Midwestern Plains</td>
</tr>
</tbody>
</table>
HAZARD
HAIL

- **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

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

- 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
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)
• 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

- Distinct functions for Hail, Tornado, and Wind
- Hail $\rightarrow$ 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 $\sim$10-15 years for most types)
- Tornado $\rightarrow$ F-rating
  - Relates damage to approximate wind speed range
- Straight-line winds $\rightarrow$ peak gust
  - Dominant range of wind speeds < 80 mph
  - Tree damage
- Use of claims data and consultants for calibration/validation
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
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
• 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

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

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

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Construction</th>
<th>Occupancy</th>
<th>Yr Built</th>
<th># of Stories</th>
<th>AAL</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>$82</td>
<td>32.7</td>
</tr>
<tr>
<td>2</td>
<td>Wood</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>$107</td>
<td>27.0</td>
</tr>
<tr>
<td>3</td>
<td>Wood</td>
<td>SFD</td>
<td>Unknown</td>
<td>Unknown</td>
<td>$123</td>
<td>23.6</td>
</tr>
<tr>
<td>4</td>
<td>Wood</td>
<td>SFD</td>
<td>1995</td>
<td>Unknown</td>
<td>$113</td>
<td>25.0</td>
</tr>
<tr>
<td>5</td>
<td>Wood</td>
<td>SFD</td>
<td>1995</td>
<td>2</td>
<td>$97</td>
<td>27.2</td>
</tr>
</tbody>
</table>
## AAL BY PRIMARY CHARACTERISTICS

<table>
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<tr>
<th>Scenario</th>
<th>Construction</th>
<th>Occupancy</th>
<th>Yr Built</th>
<th># of Stories</th>
<th>AAL</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Wood</td>
<td>SFD</td>
<td>2005</td>
<td>2</td>
<td>$95</td>
<td>27.8</td>
</tr>
<tr>
<td>7</td>
<td>Wood</td>
<td>SFD</td>
<td>1965</td>
<td>2</td>
<td>$107</td>
<td>25.5</td>
</tr>
<tr>
<td>6</td>
<td>Wood</td>
<td>SFD</td>
<td>2005</td>
<td>2</td>
<td>$95</td>
<td>27.8</td>
</tr>
<tr>
<td>8</td>
<td>Wood</td>
<td>SFD</td>
<td>2005</td>
<td>1</td>
<td>$115</td>
<td>24.7</td>
</tr>
</tbody>
</table>
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
SECONDARY MODIFIERS

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

<table>
<thead>
<tr>
<th>Hail</th>
<th>Tornado</th>
<th>Straight-line Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Roof System Covering</td>
<td>• Foundation System</td>
<td>• Tree Density</td>
</tr>
<tr>
<td>• Cladding Type</td>
<td>• Roof Anchor</td>
<td>• Roof System Covering</td>
</tr>
<tr>
<td>• Roof Age</td>
<td>• Wind Missiles</td>
<td>• Roof Sheathing Attachment</td>
</tr>
<tr>
<td>• Mechanical and Electrical Systems</td>
<td>• Tree Density</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Cladding</td>
<td></td>
</tr>
</tbody>
</table>

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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

<table>
<thead>
<tr>
<th>Loss Metric / Return Period</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAL</td>
<td>-25%</td>
</tr>
<tr>
<td>5</td>
<td>-20%</td>
</tr>
<tr>
<td>10</td>
<td>-20%</td>
</tr>
<tr>
<td>50</td>
<td>-15%</td>
</tr>
<tr>
<td>100</td>
<td>-15%</td>
</tr>
<tr>
<td>250</td>
<td>-10%</td>
</tr>
<tr>
<td>500</td>
<td>-10%</td>
</tr>
</tbody>
</table>
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
Catastrophe risk is characterized by deep uncertainty

Resiliency in principal
Understanding implied bets

Resiliency in practice
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

- Improved capital allocation
- More profitable and agile underwriting
- Leverage your experience and claims
- Stable view of risk over time
- Take control of cat models
- Manage internal and external stakeholders
- Reflect your unique portfolio

Own View of Risk