Catastrophe Modeling

Advanced Catastrophe Modeling and Storm Reporting

October 17, 2019
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Introduction

STACEY FONG
Director, Reinsurance Solutions-Analytics, AON

Stacey has nine years of analytics experience helping clients quantify their risk to catastrophes and provide the analytics to support their reinsurance transaction.

For This Meeting We

1. Will explore the general background of catastrophe models and dive deeper into understanding basic model inputs.
2. Discuss the key model outputs that mutual companies can utilize with their organization.
3. Explore some current challenges to modeling firms.
4. Learn how reinsurance brokers, reinsurers, insurance companies, etc. are utilizing technologies for catastrophe management/modeling.
5. Understand how models can be used real time during catastrophe events.
Aon is a leading global professional services firm providing **advice and solutions in Risk, Retirement and Health** at a time when those topics have never been more important to the global economy. Aon develops insights – **driven by data and delivered by experts** – that reduce the volatility our clients face and help them maximize their performance.

**Risk**
Aon provides a wide range of commercial risk and reinsurance solutions to help clients better identify, quantify and manage their risk exposure.

- **$120B** of risk premium placed annually

**Retirement**
Aon provides actuarial, investment and bundled retirement solutions to help clients design and implement secure, equitable and sustainable retirement programs.

- **$3.3T** in assets under advisement

**Health**
Aon provides consulting, global benefits and exchange solutions to help clients mitigate rising health care costs and improve employee health and well-being.

- **$180B** of health care premiums directed annually

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**ENABLED BY**
**Data & Analytics**
Aon combines proprietary data, technology and advisory services to develop insights that help clients reduce volatility and improve performance.

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1 As of 6/30/2017, includes non-discretionary assets advised by AHIC and its global affiliates which includes retained clients and clients in which AHIC and its global affiliates have performed project services for over the past 12 months. Project clients may not currently engage AHIC at the time of the calculation of assets under advisement as the project may have concluded earlier during preceding 12-month period.
Section 1

Catastrophe Modeling Background
Evolution of Catastrophe Modeling

Pre-1980’s
- Technology advancements to understand the hazards’ risks are exposed to
  - GIS
  - Weather Satellites
  - Anemometers
  - Seismographs
- First commercial models
  - AIR 1987
  - RMS 1988
- Early capabilities to manage large portfolios of exposure
  - SQL 1989

1980’s
- Advancements in data quality and granularity
  - Known risk characteristics
  - Improved geocoding
- Additional commercial models enter the market
  - 1994 (previously Equecat)
  - 1995
  - 1997

1990’s
- Major catastrophes impact the insurance market
  - Data 1990
  - Andrew 1992
  - Northridge 1994
  - Kobe 1995
- Advancements in risk differentiation, driven by building code regulation
  - Primary risk characteristics
  - Secondary modifiers
- Early capabilities to manage large portfolios of exposure

2000’s
- Advancements in catastrophe modeling regulation and integration within business functions
  - FCGL/PM 1995
  - ASGP 38 2000
  - Solvency II 2009
- Growth of the internet for spatial data and scientific research
  - Google Earth 2005

2010’s
- The Future of Cat Modeling
  - Model customization
  - Integration with satellite technologies
  - Cloud-based computing
  - Data quality improvements
  - Scientific enhancements
  - Better representation of variable climate conditions

2018
- Niche models enter the market
  - 2007
  - 2010
  - 2011
- Post-2018
- Evolution of catastrophe modeling
The Need for Catastrophe Modeling

- Catastrophic events have caused billions of insured losses:
  
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>Hurricane Katrina</td>
<td>$76.3B</td>
</tr>
<tr>
<td>2011</td>
<td>Tohoku Earthquake</td>
<td>$35.7B</td>
</tr>
<tr>
<td>2012</td>
<td>Hurricane Sandy</td>
<td>$35.0B</td>
</tr>
</tbody>
</table>
  
- Unpredictable and infrequent nature of catastrophes
- Lack of historical information to accurately predict yearly losses
- Potential for severe losses creates the necessity to prepare
- Increase in development within disaster prone areas
# Catastrophe Model Overview

## What is a catastrophe model?
- Computer program
- Risk management tool to assess potential losses caused by natural and man-made catastrophes
- Used extensively in the insurance industry

## Benefits of catastrophe models
- Simulate thousands of years of loss experience
- Consider events that have not occurred
- Models contemplate individual and site risk characteristics

## Uses of catastrophe models
- Evaluate risk
- Control risk accumulation
- Underwrite and price catastrophe risks
- Rating and regulatory organizations
- Risk transfer

## Model Vendors in the US
- RMS
- CoreLogic
- AIR
- IF
Components of a Catastrophe Model

Hazard Event Generation
- Where?
- How Big?
- How Often?

Hazard Local Intensity
- What is the intensity of the event for a location?
- Footprint definition
- Local site conditions
  - Soil type
  - Land use
  - Elevation

Vulnerability Damage Estimation
- Consider:
  - Risk characteristics
  - Coverage type
  - Geography
- Supported by:
  - Claims
  - Engineering judgment

Financial Insured Loss Calculation
- Consider:
  - Limits
  - Deductibles
  - Reinsurance

Where? How Big? How Often?

% Intensity

- Event definition
- Peril region domain
- Frequency
- Intensity
- Hazard parameters

Supported by:
- Claims
- Engineering judgment

How does the damage get paid given the policy terms?
Data Requirements

Risk Location
- Street Address Preferred
- ZIP Code, City, County Accepted

Risk Characteristics
- Construction Type (Wood Frame, Masonry, Steel, etc.)
- Number of Stories
- Year of Construction
- Occupancy Type (Single Family, Multi-Family, Condo, etc.)
- Secondary modifiers (roof geometry, cladding, etc.)

Financials
- Value of the building split by coverage type
- Any applicable limits by peril or location
- Deductibles, either percentage or dollar by peril

Garbage in, garbage out
## Data Quality – Potential Loss Variability From Inputs

### Loss Variability Example in Florida

- **Commercial risk with largely unknown risk characteristics**
- **Testing to determine how sensitive this location can be with known risk characteristics**

#### POLICY DETAILS

<table>
<thead>
<tr>
<th>Geocoding</th>
<th>Street Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupancy</td>
<td>SIC 5199 (Non Durable Goods Wholesaling)</td>
</tr>
<tr>
<td>Year Built</td>
<td>Unknown</td>
</tr>
<tr>
<td>Construction</td>
<td>Unknown</td>
</tr>
<tr>
<td>Stories</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of Buildings</td>
<td>1</td>
</tr>
<tr>
<td>Building</td>
<td>$2,200,000</td>
</tr>
<tr>
<td>Other Structures</td>
<td>n/a</td>
</tr>
<tr>
<td>Contents</td>
<td>$13,805,000</td>
</tr>
<tr>
<td>ALE/Bi</td>
<td>$500,000</td>
</tr>
</tbody>
</table>

| Hurricane AAL | $54,861 |
| Hurricane SD | $669,832 |

**If We Change…**

<table>
<thead>
<tr>
<th>Revised AAL and SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZIP Code Geocoding or</td>
</tr>
<tr>
<td>With 1985 Year Built or</td>
</tr>
<tr>
<td>With 1985, 2 Story, Concrete Block Construction and Concrete Roof</td>
</tr>
</tbody>
</table>
Catastrophe Modeling Demonstration
Section 2

Model Utilization
Companies have historically relied heavily on outsourcing view of risk to model vendors, but now is the time to rethink the correct view of risk.
Managing Catastrophe Volatility

Enterprise Risk Management Cycle

How does cat modeling fit into Enterprise Risk Management?

Risk Assessment and Quantification
- Prioritize and rank risks
  - Catastrophes introduce volatility
- Develop quantitative risk estimates
  - Models define this volatility

Risk Mitigation
- Implement controls targeting top risks
  - Test and monitor using models
- Develop plans to mitigate risks
  - Risk transfer based on models
  - Better pricing leveraging models

Enterprise Risk Management – Facilitates the identification, management, and reporting of the organization’s key risk
Effective catastrophe risk management requires measuring and recouping all catastrophe risk cost components.
Why Total Catastrophe Cost is So Important

It is important because:

- Models identify gross AAL only
- Cost of concentration, cost of volatility will vary by risk bearers
- Risk sensitive pricing drives portfolio diversification

Risk sensitive pricing is critical when pricing catastrophe risk
Section 3

Catastrophe Modeling Challenges
Modeled Vs. Non-Modeled Perils

Percentage of occurrences of natural disasters by disaster type (1995-2015)

- Flood: 43%
- Storm: 28%
- Earthquake: 8%
- Extreme temperature: 6%
- Landslide: 5%
- Drought: 5%
- Wildfire: 4%
- Volcanic activity: 2%

Numbers of people affected by weather-related disasters (1995-2015)

- Flood: 56%, 660 million
- Storm: 26%, 1.1 billion
- Extreme temperature: 16%
- Landslide & Wildfire: 5%

Source: UN/CRED
Key Non-Modeled Aspects of Recent Events: EQ and HU

Earthquake:
- Christchurch Sequence
  - Clustering/Aftershocks
  - Liquefaction
  - Landslide
- Tohoku
  - Tsunami
  - Fukushima (Nuclear Power)
  - Contingent Business Interruption

Hurricane:
- Sandy
  - Secondary effects in Midwest and Northeast
  - Inland Flooding
- Katrina
  - Subsea pipelines in the Mississippi Delta
- Ivan
  - Levee failure
  - Extreme loss amplification
  - Policy leakage (flood losses from wind policy)
- Ike
  - Government intervention in application of deductibles
  - Non-modeled LOB (auto / marine)
  - Pollution
  - Fire following flood

Source: “Non-Modelled Risks: A guide to more complete catastrophe risk assessment for (re)insurers.” Association of British Insurers
Increasing Need for Understanding Wildfire Risk

First Generation Models
- CoreLogic 2004
- IF 2004
- AIR 2006

Wildfire Severity on the Rise
- 2003 Cedar Fire
- 2007 Witch
- 2015 Valley

Worst Seasons Yet
- 2017
- 2018

Major Events in 1990s
- 1991 Oakland Hills most significant

Underwriting and Risk Selection
How do I select the best risks for my portfolio?

Accumulation Management
How and where can I grow? Do I have too many risks in high hazard areas?

Pricing
How can I differentiate and price competitively?

Damage associated with a wildfire can result in a loss that may not be appropriately accounted for in current models.
Q: What if past storms had instead formed near the end of the century?

Answer: A bit stronger, a bit loser, and a lot wetter in a warmer climate

The biggest issue is around water: with a warmer atmosphere, rainfall rates are expected to increase in the future.
Managing to an Evolving Terrorism Threat

Both property and workers compensation exposure must be considered when quantifying total risk during terroristic events.
# Cyber Risk Modeling

## Risk Components

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Nat Cat</th>
<th>Cyber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentrations of risk</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Hazard

<table>
<thead>
<tr>
<th>Frequency and severity</th>
<th></th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Threat actors</th>
<th>Data impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nation states</td>
<td>Confidentiality</td>
</tr>
<tr>
<td>Criminals</td>
<td>Integrity</td>
</tr>
<tr>
<td>Hacktivists</td>
<td>Availability</td>
</tr>
<tr>
<td>Hobbyists</td>
<td></td>
</tr>
</tbody>
</table>

## Vulnerability

<table>
<thead>
<tr>
<th>Susceptibility to hazards</th>
<th>Vulnerabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Security hygiene and defense</td>
</tr>
</tbody>
</table>

Note: Companies listed for software and service provider exposure are representative and not meant as an exhaustive list.

## Cyber incident trends

In Q1 and Q2 alone, cyber incidents in 2019 have already outpaced 2015 and 2016 totals.

Exhibit 1: Cyber incidents by year

<table>
<thead>
<tr>
<th>Year</th>
<th>Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY15</td>
<td>3,391</td>
</tr>
<tr>
<td>FY16</td>
<td>3,252</td>
</tr>
<tr>
<td>FY17</td>
<td>5,648</td>
</tr>
<tr>
<td>FY18</td>
<td>5,858</td>
</tr>
<tr>
<td>H119</td>
<td>3,718</td>
</tr>
</tbody>
</table>

Section 4

Innovation in Catastrophe Modeling
Catastrophe modeling is now fully integrated into insurance companies, reinsurance brokers, and reinsurers – so what is next?
Learning and Its Impact on Cat Modeling

AI – Machine Learning – Deep Learning

ARTIFICIAL INTELLIGENCE
Programs with the ability to learn and reason like humans

MACHINE LEARNING
Algorithms with the ability to learn without being explicitly programmed

DEEP LEARNING
Subset of machine learning in which artificial neural networks adapt and learn from vast amounts of data

A.I. powered solutions for the insurance industry are no longer dreams, but are powerful tools that are fundamentally changing how carriers operate
Aon Partnerships – Wildfire Risk Score

Z-FIRE™ Wildfire Risk Score

Building Density and Vegetation Density at the Property Level

Building and Vegetation Outlines Generated by Zesty.ai’s Artificial Intelligence Models
Primary Defensible Space (30 ft) and Secondary Defensible Space (50 – 100 ft) around Property

Capture and price for catastrophe volatility that wildfire poses
Remote sensing allows for unparalleled access to real time risk characteristics

- Data capture and data validation are key components of the insurance value chain.
- Many current processes are paper, manual entry, or insured entry based. These methods can lead to data mistakes or erroneous data entry.
- Satellite and drone imagery can facilitate high quality data capture and validation driving underwriting and consumer experience benefits.
Modernizing Cat Modeling Workflows Using APIs

Customers expect speed and accuracy
Modeling and analysis are more complex
Pricing leverage is at historical lows

The need for greater operational and financial efficiencies has driven the demand for automation

Proprietary & Confidential
Section 5

Catastrophe Response
Aon Real-time Hurricane Response

Impact Forecasting
Automated Event Response (AER) loss and claims estimates

5 days pre-landfall through dissipation

5-7 days before landfall

7-14 days post-landfall

Final client portfolio loss estimates from model vendors and official industry loss estimates

2 days +/- landfall

Daily exposure and Stochastic loss estimates

Expert event briefings and situational support from Aon’s team of meteorologists

Model performance analysis

Post-event

Proprietary & Confidential
Aon’s Impact Forecasting Automated Event Response

Automated National Hurricane Center Forecasts

- Real-time hurricane modeling
- Events created based on actual hurricane forecasts
- Automated updates to a company’s e-mail inbox
- Detailed loss estimates

Example hurricane loss estimate progression

Wind speed footprints:

[Map of hurricane impact with wind speed gradients]

Sat  Sunday  Monday  Tuesday  Wednesday  Thursday

<table>
<thead>
<tr>
<th>Kilometers</th>
</tr>
</thead>
<tbody>
<tr>
<td>14,000</td>
</tr>
<tr>
<td>12,000</td>
</tr>
<tr>
<td>10,000</td>
</tr>
<tr>
<td>8,000</td>
</tr>
<tr>
<td>6,000</td>
</tr>
<tr>
<td>4,000</td>
</tr>
<tr>
<td>2,000</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Landfall
Demonstration of Aon Tools for Cat Response

So what does this process actually look like?

Demonstration of Aon’s Analytics Dashboard catastrophe response dashboard

Demonstration of Aon’s ImpactOnDemand event reporting capabilities
How cat models make communities more resilient

A combination of hurricanes, wildfires, cyclones, and droughts led to two of the costliest years in a row in terms of weather and climate-related disasters. The combined economic toll of all the natural disasters for both years was $675 billion – with insurers covering roughly one-third of that cost. In fact, 2018 alone saw 42 separate billion-dollar natural disaster events and a total global economic loss of $225B.

— THE ONE BRIEF – AON 1/31/2019

There is the potential for the insurance industry to play an even larger role in improving the resiliency of communities post event… And Catastrophe Models can help
In Conclusion, For this Meeting We

- Explored the general background of catastrophe models and dive deeper into understanding basic model inputs
- Discussed the key model outputs that mutual companies can utilize with their organization
- Explored some current challenges to modeling firms
- Learned how reinsurance brokers, reinsurers, insurance companies, etc. are utilizing technologies for catastrophe management/modeling
- Now understand how models can be used real time during catastrophe events

THANK YOU.

Q&A...