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GRIFFITH FOUNDATION
PRESENT
Back to Basics: Climate Risk–Financial Resilience
JANUARY 23RD
12PM CENTRAL
NAIC | CENTER FOR INSURANCE POLICY AND RESEARCH

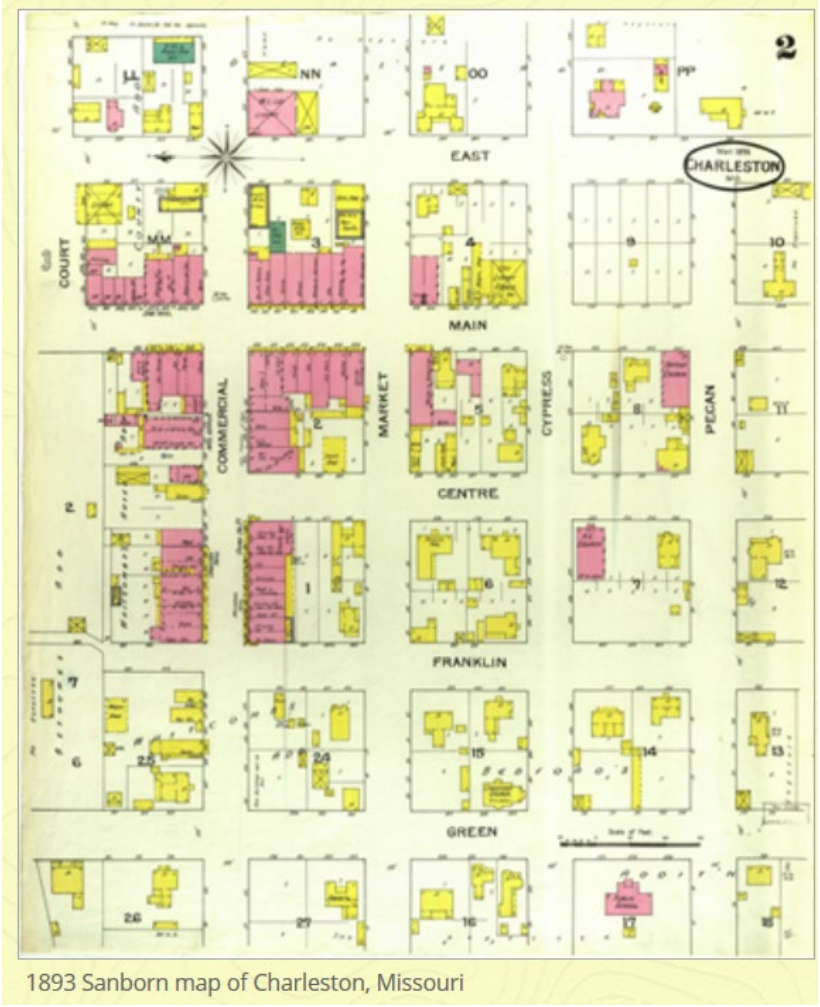
An Overview of Catastrophe Modeling

Dr. Randy Dumm
Director, Baldwin Risk Partners School of Risk Management and Insurance
University of South Florida

Risk aggregation analysis (pre-1980s)

Risk Mapping is visual:

- **color codes**
- **pins**



1893 Sanborn map of Charleston, Missouri

Our Story begins in 1989

SEPTEMBER 25, 1989

Business Insurance

Reporting weekly for corporate risk, employee benefit and financial executives / $1.75 a copy; $70 a year

California governor expected to sign workers comp reforms

SACRAMENTO, Calif.—California Gov. George Deukmejian is expected to sign a workers compensation reform package unanimously passed last week by the Legislature that would, among other things, increase the maximum weekly benefit for injured workers and establish a process for helping workers obtain vocational rehabilitation services.

"It's a good first step," said John Lewis, an attorney in Coconut Grove,

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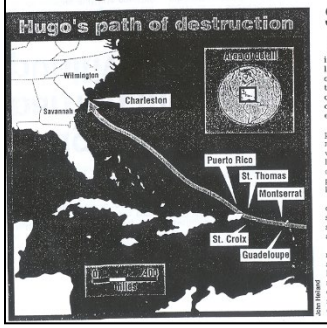
Hugo's wrath hits insurers

Storm could be most costly on record



Hurricane Hugo, which slammed into the coast of South Carolina late last week after cutting a path of death and destruction through the Caribbean, could cause billions of dollars in damage and rank as one of the most expensive storms ever.

Damage from the storm, which packed winds of more than 135 mph early Friday morning when it walloped the coast of South Carolina, also could spell the beginning of the end of the soft commercial property/casualty insurance market, some observers say.

However, others maintain that, despite the devastation, the losses spawned by Hugo will not in themselves cause insurance and reinsurance rates to rise.

Hugo already had caused as much as $1 billion in insured damages in the Caribbean islands from Montserrat to Puerto Rico before it reached the U.S. mainland, some observers estimated, though others said it was too early to assess the damage in the Caribbean, much less the devastation in the Southeast.

The bulk of the insured damages in the Caribbean were personal lines losses, sources reported.

The Property Claims Services division of the New York-based American Insurance Services Group expects to have a preliminary damage estimate this week.

Early reports from Charleston, S.C., on Friday said the storm caused extensive damage. One unconfirmed report said that at least 22 major buildings in downtown Charleston suffered heavy damage. The heaviest damage was thought to be on the barrier islands off Charleston, though communication with the islands was virtually impossible Friday.

"It could be at least 60% of the 'Big One,'" said a senior Lloyd's reinsurance brokerage executive, referring to the scenario of a hurricane whipping up the East Coast and hitting New York. Industry officials have estimated that a hurricane hitting New York could cause between $6 billion and $15 billion in damage (*BI*, Sept. 18).

If damages from Hugo constitute the "worst-possible" scenario and exceed $4 billion, "I don't see how it doesn't tighten the market," said Myron M. Picoult, senior vp and senior insurance analyst with Oppenheimer & Co. in New York. "It will clean a lot of cash clocks," he said on Friday.

"If that doesn't tighten the market, there is something really wrong with the people running the industry," Mr. Picoult said.

However, if damage from Hugo totals only about $2 billion, "we are close to the point of maybe yes or maybe no," he said, referring to a turn in the market.

However, no matter how much damage Hugo causes, "it going to squeeze the cash flows, which is a positive sign," he said.

"It's premature to judge" what impact Hugo will have, said Herbert E. Goodfriend, securities analyst with Prudential/Bache Securi-

Continued on page 38

Hurricane Hugo damaged an estimated 300,000 buildings in Charleston, S.C., alone.

AP

Hugo's toll

Worst storm ever to cost insurers at least $4 billion

The flood of claims created by Hurricane Hugo, now acknowledged by the insurance industry as the costliest storm on record, will not be enough to immediately douse property/casualty insurance rate cutting, many industry observers contend.

The Property Claims Services division of American Insurance Services Group Inc. late last week estimated that Hugo caused $3.984 billion of insured property damage in the United States, Puerto Rico and U.S. Virgin Islands, a record for a storm-related loss.

However, many observers predicted the full cost of the storm—especially business interruption claims from devastated Charleston, S.C.—will not be known for months.

"The sleeping dog in this whole thing will be business interruption losses," predicted Robert Hastings, a vp in the Charlotte, N.C., office of Johnson & Higgins.

"I'm sure we'll be tallying claims from this one a year or two from now. It's something that could take Charleston 10 years to clean up," said Lucy Allison, a claims manager in the Charleston office of Corroon & Black Corp.

An estimated 300,000 structures were damaged in the Charleston area alone, according to Emmett Kennedy, assistant catastrophe manager in the Dallas office of GAB Business Services Inc. and head of GAB's South Carolina operations.

According to AISG's estimates, insured damage in South Carolina totals an estimated $2.553 billion, including $1.52 billion in the four coastal counties of Charleston, Horry, Georgetown and Berkeley. North Carolina losses are estimated at $275 million, while damage in Virginia and Georgia is set at $5 million and $1 million, respectively.

Hugo is unlikely to trigger a major turnaround in the reinsurance marketplace, U.S. reinsurance executives say. See story, page 51.

Meanwhile, insured property damage is estimated at $700 million in Puerto Rico and $450 million in the U.S. Virgin Islands, AISG announced.

These estimates do not include roughly $500 million in flood losses covered by the National Flood Insurance Program and by private insurers participating in the federally-backed "write-your-own" flood insurance program.

Continued on page 53

Quake's insured losses estimated at $1 billion

By MICHAEL BRADFORD and LOUISE KERTESZ

While the California earthquake will cost insurers about $1 billion, or only a fraction of the up to $10 billion in total damage, the "psychological" impact of a disaster coming on the heels of Hurricane Hugo could increase property insurance rates, brokers say.

The Property Claims Services Division of the American Insurance Services Group estimated Friday that the net insured loss to buildings and vehicles in California from the quake is $960 million.

The earthquake increased total catastrophe losses in the United States this year through Oct. 17 to a record $6.6 billion. That figure does not include damage caused by last week's explosion at a Phillips Petroleum Co. petrochemical complex in Pasadena, Texas (see related story).

Even excluding the Phillips loss, this year's catastrophe toll far exceeds the previous industrywide record of $2.82 billion set in 1985.

Meanwhile, an AISG survey of insurers reveals that losses from Hurricane Hugo are slightly lower than a preliminary estimate of $3.98 billion. However, the preliminary estimate of Hugo's damage is not being revised since the latest survey is part of an interim progress report. A final estimate of Hugo claims will not be prepared for three months.

The California Insurance Department also estimates that insured losses from the earthquake will $1 billion. But Assistant Insurance Commissioner Richard Roth noted that

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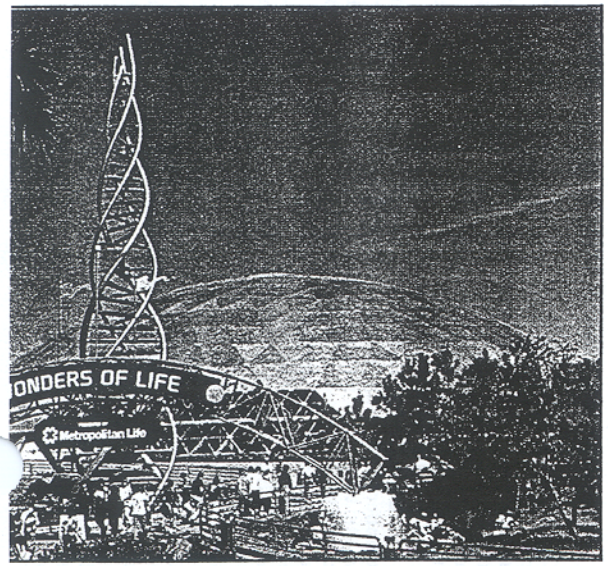
1989 Becomes a Record Year

NATIONAL UNDERWRITER

RECEIVED NOV 22 1989

NOVEMBER 20, 1989
NUMBER 47 □ 93RD YEAR



E has opened its gold-domed, 100,000 square foot 'Wonders of Disney World's Epcot Center, Orlando, Fla. See story, page seven.

'89 Marks Worst Year For Property Losses

31 Catastrophes To Cost Insurers $6.63 Billion

BY ROBERT G. KNOWLES

CHARLESTON, S.C.—With 42 days left to go, 1989 already has become the worst year in American history for catastrophic property insurance losses.

"There has never been a year to rival 1989," Property Claim Services Division Manager William A. Gilluly told reporters at a news conference in Charleston's hurricane-ravaged historic district.

He said the private insurance industry expects to pay a total of $6.63 billion for insured property losses incurred by policyholders in 31 catastrophes thus far this year.

As Mr. Gilluly spoke, almost two months after Hurricane Hugo struck the South Carolina lowlands, the roar of chain saws and power tools still rattled windows in the area. The Category 4-storm smashed into the Carolinas on Sept. 21-22.

"Natural catastrophes in the second quarter of the year produced the greatest amount of insured property damage in the United States of any

What we should have known…

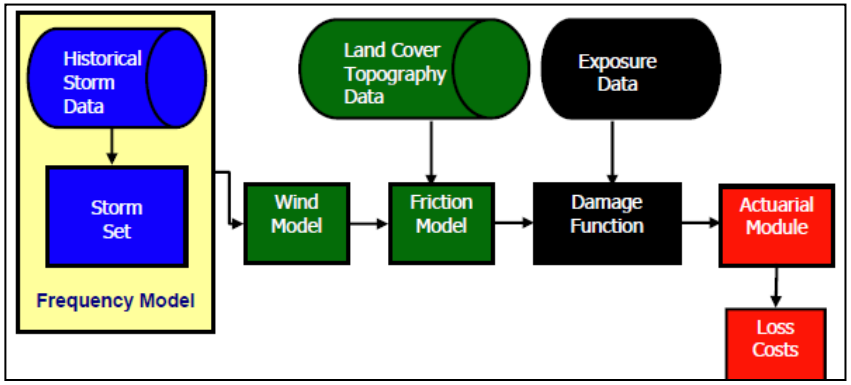
NOAA

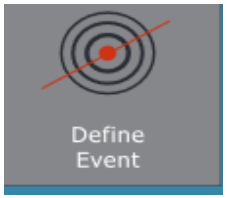
Post-Andrew Outcomes

- Aggregation of risk not well understood
- Building codes matter
- Traditional approach for pricing risk with catastrophic elements does not work.
- Need for a new approach- computer-based catastrophe models
- Need to see inside the “black box”
  - Florida Commission on Hurricane Loss Projection Methodology
- Changes to ASOP

Catastrophe Model Specifics

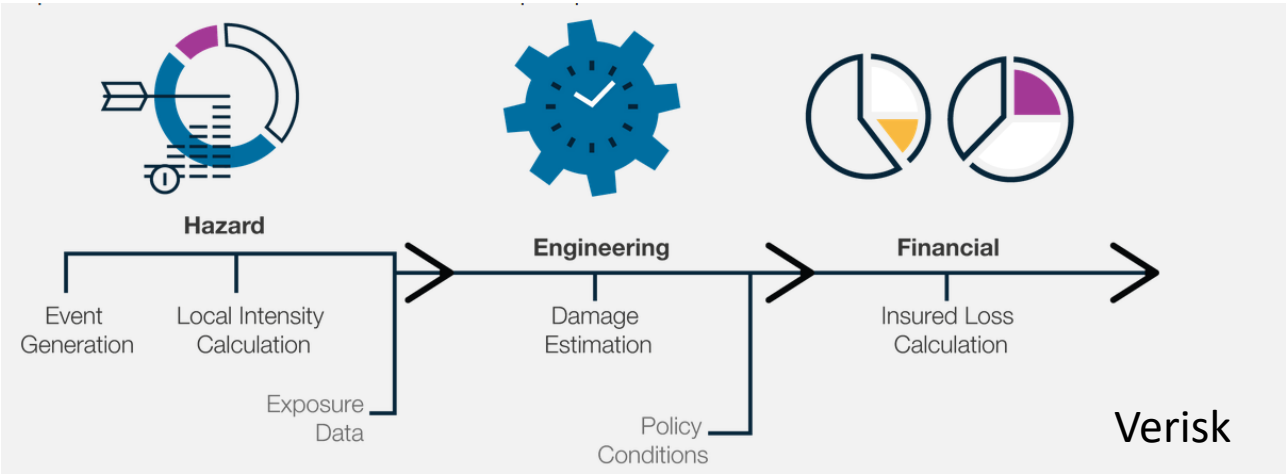
The Catastrophe Model Framework





- **Stochastic Event Module**
- **Hazard Module**
- **Vulnerability Module**
- **Financial Module**

RMS: A Guide to Cat Modelling



Model Output Example

PML Summary

10k Standard, No Storm Surge, With/Without Demand Surge, Per Occurrence Basis

With Demand Surge		Loss Est
Probability	**Return Period**	
	EV/AAL	8,459,103
5.0%	***20***	***39,368,866***
2.0%	*50*	83,131,577
1.0%	***100***	***134,305,809***
0.4%	*250*	231,308,686
0.2%	*500*	313,161,930
0.1%	*1,000*	399,306,693

EX Demand Surge		Loss Est
Probability	**Return Period**	
	EV	7,595,024
5.0%	***20***	***35,307,742***
2.0%	*50*	73,108,706
1.0%	***100***	***115,295,554***
0.4%	*250*	194,177,943
0.2%	*500*	264,634,442
0.1%	*1,000*	323,755,048

What Catastrophic Risks are Modeled?

- Extreme Wind
- Flood
- Earthquake
- Tsunami
- Fire
- Climate
- Cyber
- Pandemic
- Terrorism
- Others

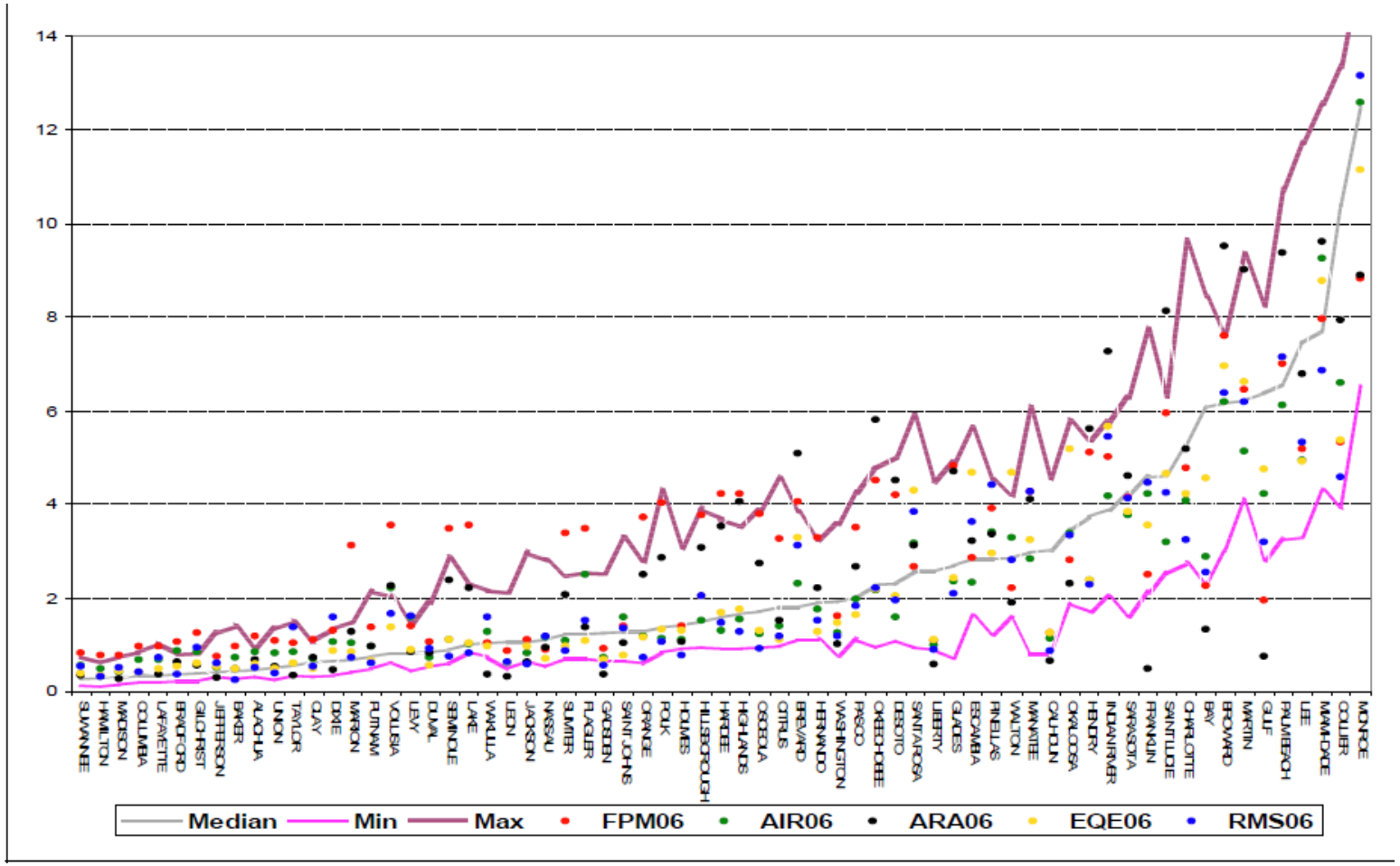
Who Models Catastrophic Risk?

- **Vendor Models**
  - Verisk
  - Risk Management Solutions
  - CoreLogic
- **Others**
  - Applied Research Associates
  - Florida Public Hurricane Loss Model
  - Karen Clark & Company
  - Broker Models
  - Internal models

Who Uses Catastrophe Models?

- Insurers
- Reinsurance
- Reinsurance brokers
- Rating agencies
- Government entities/regulators
- Capital market participants
- Researchers

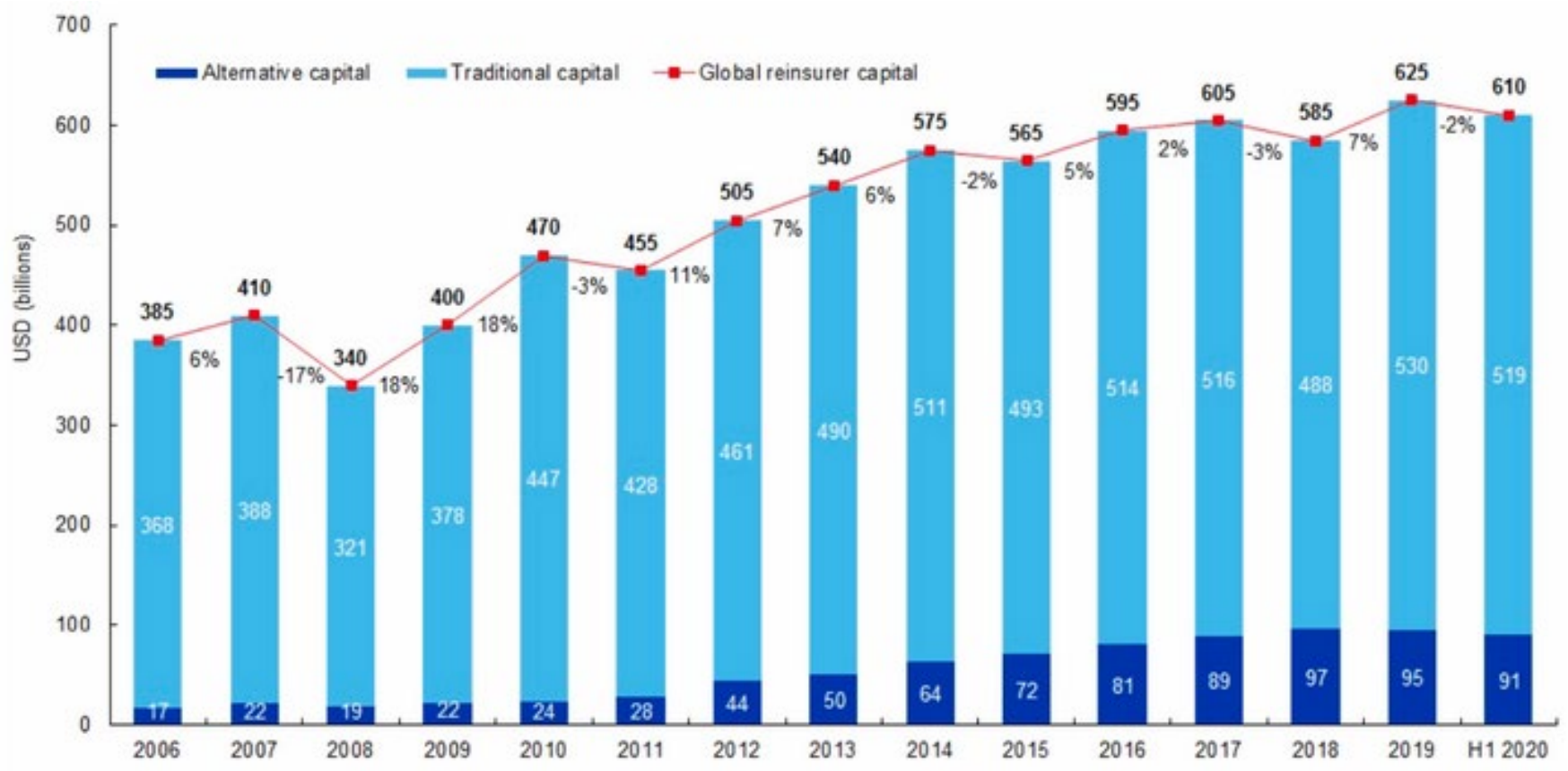
Models Produce Different Results



Model Challenges and Development

- **Model Performance**
  - **2004-2005 hurricane seasons**
  - **Model projections- Hurricane Katrina**
  - **Model Changes Post Hurricane Ike**
  - **Large Between-Model Loss Estimates**
- **Climate change concerns and model versions**
    - **Traditional versus near/short-term models**
- **Model Expectation and Uncertainty**

Models and ILS Growth



Sources: Company financial statements / Aon Business Intelligence / Aon Securities Inc.

"All models are wrong, but ~~some~~ [they] are [indeed] useful"
(Apologies to George E. P. Box, 1976!)

" The emergence of catastrophe modeling has brought a new era of risk assessment, enabling insurance experts to comprehend and mitigate complex perils driven by environmental factors." (Waterstreet, 2023)

"With all the advances in the science and computing power we need to adopt, embrace new methodologies [and] new ways of building accurate models" (Karen Clark, 2022)

Key NAIC Nat Cat and Climate Related Solvency Activities

Bruce Jenson
Assistant Director, Solvency Policy
National Association of Insurance Commissioners

Key NAIC Nat Cat and Climate Related Solvency Activities

- 2010 – Initial NAIC Climate Risk Disclosure Survey launched
- 2013 – Climate change guidance added to NAIC Examiners Handbook
- 2017 – RCAT charge added to RBC for hurricane/earthquake
  - Wildfire charge effective 12/31/23
  - Convective storm 12/31/23 for information purposes only
- 2020 – NAIC Climate & Resiliency (EX) Task Force established
  - Solvency Workstream
- 2022 – NAIC adopts updated Climate Risk Disclosure Survey aligned with the international Task Force on Climate-Related Financial Disclosures (TCFD)

Key NAIC Nat Cat and Climate Related Solvency Activities

- 2022 – NAIC establishes a new Center of Excellence for CAT Modeling to support regulators
- 2023 – NAIC adopts updated guidance for Financial Analysis and Examination handbooks
- Pending Developments:
  - Property/Casualty Data Call
    - Zip code level data on Homeowners policies
  - Climate Scenario Analysis
    - Medium-term scenario proposed for collection with RCAT
  - CAT Reinsurance Program Description
    - Proposed RBC RCAT Interrogatory

NAIC Financial Analysis Handbook – 2023 Updates

Credit, Market and Liquidity Repositories:

- Assess the potential risk of climate change/transition and asset devaluation risk on insurer's invested assets by utilizing information in:
  - SEC filings (if applicable)
  - ORSA filings (if applicable)
  - Climate Risk & Disclosure Survey (if applicable)
  - NAIC's U.S. Insurance Industry Climate Affected Investment Analysis

NAIC Financial Analysis Handbook – 2023 Updates

Pricing/Underwriting and Strategic Repositories:

- Assess the insurer's exposure to Catastrophic Events including potential for increased physical losses, prospectively, due to climate change
  - RBC
  - ORSA
  - Climate Risk & Disclosure Survey
  - Other information (e.g., Cat Modeling used by the insurer)
- Assess the adequacy of CAT reinsurance coverage in place
  - Use of CAT modeling results in reinsurance decision-making (e.g., retention levels, coverage limits, exclusions, reinstatement provisions, or use of non-traditional reinsurance).

NAIC FinancialExam Handbook – 2023 Updates

Repositories

Investments

Reinsurance (Assuming and Ceding)

Underwriting

Exhibits

Exhibit A (Planning Procedures)

Exhibit B (Planning Questionnaire)

Exhibit DD (Critical Risk Categories)

Exhibit I (Planning Memo)

Exhibit V (Prospective Risks)

Exhibit Y (Interview Questions)

Example Risks – Underwriting Repository

Identified Risk	Possible Controls	Test of Controls	Detail Tests
Insurer has not established CAT risk exposure limits	Concentration limits set by peril and zone through scenario analysis or CAT modeling	Verify that limits are set and enforced through underwriting practices and/or reinsurance coverage	Evaluate the appropriateness of limits in comparison to capital position, industry standards, etc.
CAT risk exposure calculations are not produced by a reliable process	Controls over: • Input data • Model assumptions • Non-modeled risks • Model validation	Review data reconciliations, rationale for assumptions, validation reports, etc.	Test accuracy of input data, consider engaging specialist to review modeling assumptions, backtest modeled results.

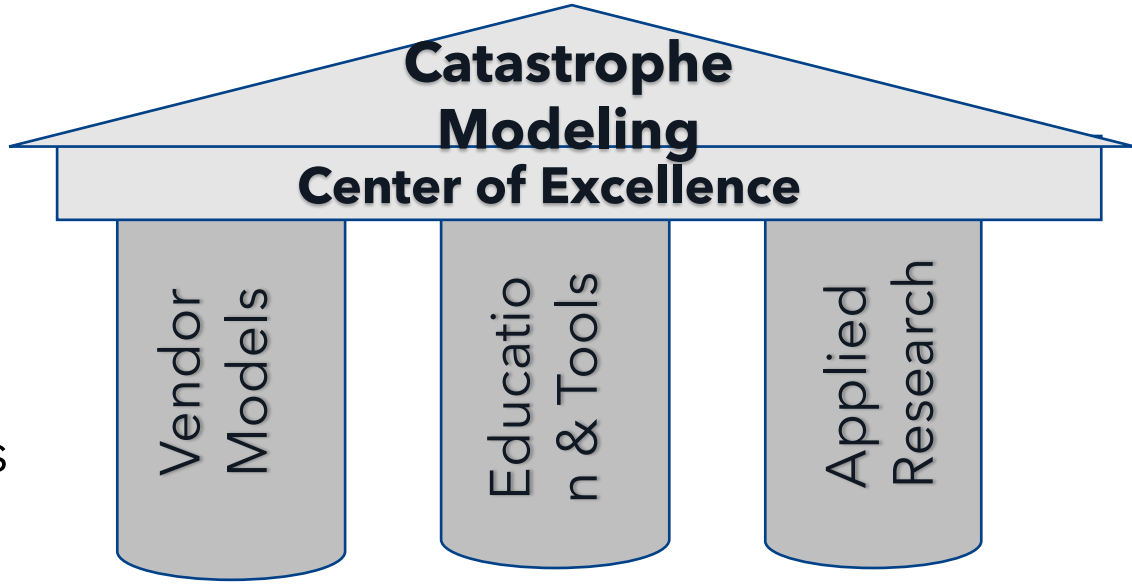
Exhibit V – Prospective Risk Example

- Example Risk
  - The company may experience increased frequency and/or severity of natural hazards due to climate change, impacting its ability to achieve its long-term business strategy.
- Risk Mitigation
  - Short-term scenario results presented in the ORSA report.
  - Medium-term scenarios projected over 5-10 year horizon and used for strategic planning
    - Significant increase in loss costs may require changes in UW/Reinsurance strategy or additional capital.
    - Evaluating impact on long-term business strategy with plans to present recommendations to BOD.
- Examiner Review
  - Review the short-term scenarios outlined in ORSA to stress UW results and CAT cover.
  - Review the medium-term stress scenarios to assess impact
  - Refer to analysis for on-going monitoring, including review of BOD recommendations.

CAT Modeling COE

To provide regulators with:

1. Access to information on vendor models
2. CAT education designed for regulators
3. CAT research projects requested by regulators



GuyCarpenter

INDUSTRY EFFORTS TO STRENGTHEN FINANCIAL RESILIENCE

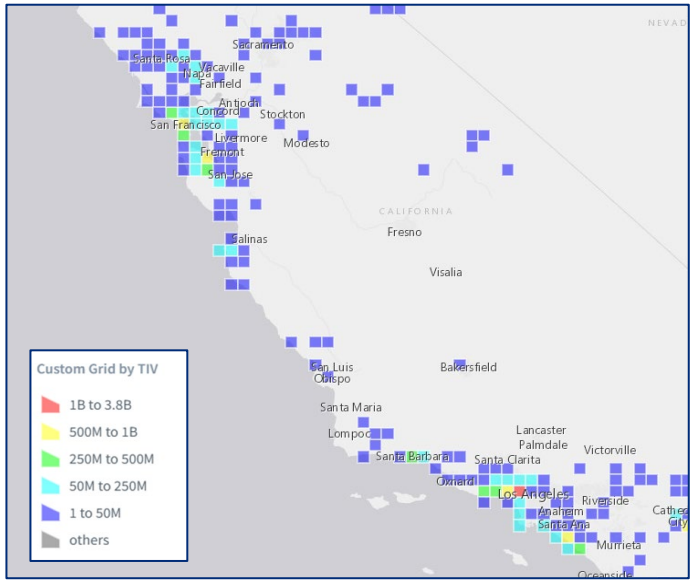
Susan Denike
January 23, 2024

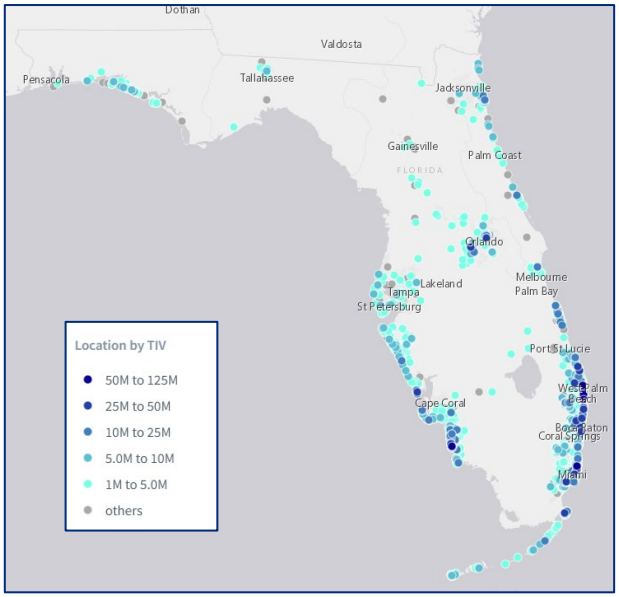
Climate Risk and the Insurance Industry

- Climate change could threaten the financial health of insurers, and cause disruptions in the availability and affordability of coverage if insurers become more risk averse as a result.
- Insurance companies could face higher losses and potential increased frequency and severity of events could make existing catastrophe models and pricing practices less effective.
- Risk Mitigation efforts including more robust building codes, research into resilient construction practices and retrofitting have shown encouraging results in recent events and will continue to evolve and improve.
- There is also a role for nature-based solutions: actions to protect, sustainably manage, or restore natural ecosystems.
- Proper evaluation and quantification of the current and future risk to insurers' portfolios should consist of:
  - Exposure Management
  - Hazard Mapping
  - Catastrophe modeling

Exposure Management

- Insurers must continue to invest in high-quality, high-resolution data collection
- Underlying data must be Complete, Correct and Current
- Align valuations with current costs of rebuilding
- Mitigation efforts need to be reflected in exposures modeled
- Utilize third-party tools for data augmentation – Hazard Scoring / Insurtech
- Leverage mapping tools to reveal “hot spots” of exposure concentrations



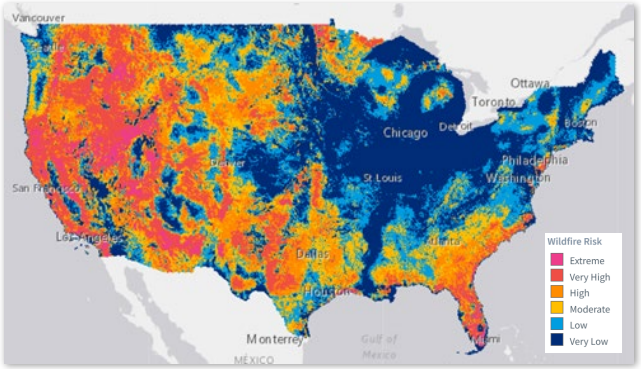


Stress Exposure for Climate Scenarios

Hazard Mapping

- Hazard maps are an effective way to provide quantitative risk-differentiating metrics for specific locations
- Hazard mapping and scoring can also be used to help insurers understand the regional and site-specific impacts of specific perils resulting from different climate stresses.

US Wildfire



Present Day

Total Portfolio

Wildfire Risk Category	TIV	% Tot	% Agg	Building Value	% Tot	Risks	% Tot
Extreme	32,971,130	0.0%	0.0%	27,996,382	0.0%	109	0.1%
Very High	2,398,801,261	2.4%	2.4%	2,046,881,623	2.4%	3,275	1.5%
High	5,548,486,342	5.5%	7.9%	4,843,767,471	5.7%	8,048	3.7%
Moderate	7,005,284,553	7.0%	14.9%	5,964,855,616	7.0%	16,765	7.7%
Low	15,643,624,959	15.5%	30.4%	13,109,870,202	15.4%	42,464	19.6%
Very Low	70,006,461,591	69.6%	100.0%	58,982,461,056	69.4%	145,937	67.4%
	100,635,629,837	**100.0%**		**84,975,832,349**	**100.0%**	**216,598**	**100.0%**

2050

Total Portfolio

Wildfire Risk Category	TIV	% Tot	% Agg	Building Value	% Tot	Risks	% Tot
Extreme	51,508,544	0.1%	0.1%	42,071,381	0.0%	162	0.1%
Very High	2,796,039,024	2.8%	2.8%	2,385,467,898	2.8%	3,809	1.8%
High	5,798,740,717	5.8%	8.6%	5,081,061,604	6.0%	8,766	4.0%
Moderate	7,473,040,647	7.4%	16.0%	6,323,952,626	7.4%	18,063	8.3%
Low	16,060,720,060	16.0%	32.0%	13,438,086,397	15.8%	44,279	20.4%
Very Low	68,455,580,845	68.0%	100.0%	57,705,192,443	67.9%	141,519	65.3%
	100,635,629,837	**100.0%**		**84,975,832,349**	**100.0%**	**216,598**	**100.0%**

RCP 4.5 (2050) is described by the Intergovernmental Panel on Climate Change (IPCC) as a moderate/intermediate scenario in which emissions peak around 2040 and then decline.

Modeled output

Stress for Climate Scenarios

- Models are built and calibrated to historical loss severity and event frequency.
  - Prior to selecting Stress scenarios, evaluate if current model is fit for purpose - an uplift of loss may be required to represent the present-day risk accurately.
  - Vendors have long provided the ability to adjust hurricane frequency based on a “near term” event set.
- Most catastrophe model climate adjustments focus on the peril of North Atlantic Hurricane
  - Catastrophe model output is derived from thousands of event scenarios each representing an event of a particular severity occurring at a particular geographic location. Each will have an associated likelihood of occurring
  - Vendors have released scenario files giving the user the ability to apply model adjustments with a specific focus on changing climate.
  - Users can adjust frequency and severity for future climate change projections, at various time horizons
- Tools also exist for quantifying potential increased severity and frequency of flooding, wildfire, severe storms (incl. Hail) and Winter storms.

Innovation is needed to ensure adequacy of coverage

Traditional and Non-Traditional Risk Financing

- Catastrophe risk is currently funded through a variety of sources, including:
  - Insurance Companies
  - State-Based Insurance Funds and Pools and Reinsurance Funds
  - FEMA (Flood)
  - Traditional Insurance and Reinsurance
  - Catastrophe Bonds
- As climate-related weather risks become increasingly complex and unpredictable and potentially more severe, the need for innovative insurance structures rises:
  - Parametric (Re)Insurance: Alternative Risk Solution with a triggered payout, indexed-based cover
    - Example: New York MTA MetroCat Parametric Cat Bond
  - Public/Private Partnerships: Address protection gaps

Key Takeaways

The dynamics of a changing climate will challenge the insurance and reinsurance industry to manage capital, evaluate and execute growth plans while adapting to shifts in volatility.

There is no one solution for understanding climate change, quantifying the financial impact and proactive management of a peril impacted by a changing climate.

Insureds, regulators, insurers, academic institutions, modeling vendors and reinsurers all have a role to play to ensure that insurance remains available and affordable and that protection gaps

PHOTOGRAPH: JOE RAEDLE/GETTY IMAGES

GuyCarpenter

About Guy Carpenter

Guy Carpenter & Company, LLC is a leading global risk and reinsurance specialist with 3,400 professionals in over 60 offices around the world. Guy Carpenter delivers a powerful combination of broking expertise, trusted strategic advisory services and industry-leading analytics to help clients adapt to emerging opportunities and achieve profitable growth. Guy Carpenter is a business of Marsh McLennan (NYSE: MMC), the world's leading professional services firm in the areas of risk, strategy and people. The Company's 86,000 colleagues advise clients in 130 countries. With annual revenue of over $20 billion, Marsh McLennan helps clients navigate an increasingly dynamic and complex environment through four market-leading businesses including Marsh, Mercer and Oliver Wyman. For more information, visit www.guycarp.com and follow us on LinkedIn and Twitter.

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