Natural Catastrophe Modeling

Devashish Kumar, Feb 24, 2012
CEE, SDS Lab @ Northeastern University

Education

- B.Tech. in Civil Engineering

भारतीय प्रौद्योगिकी संस्थान खड़गपुर
Indian Institute of Technology
Kharagpur

- M.S. in Civil & Environmental Engineering
  - Computational Mechanics

UNIVERSITY OF SOUTH FLORIDA

Experience: Baker Engineering and Risk Consultants

- Quantitative Risk Assessment of Industrial Structures subjected to accidental explosions
- BP, Shell, Conoco Philips, Exxon Mobil, Schlumberger, US Dept of State
- Performed Finite Element Analysis of a storage tank for a law firm to support accident investigation
- Designed a new Shock tube for the University of Ontario, Canada

Shock Tube@ Baker Engineering and Risk Consultants

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Experience: Swiss Reinsurance Company (Swiss Re)

- Estimated unbiased risk premium of insurance portfolios exposed to natural perils such as hurricanes, earthquakes, and tornados

- Performed loss analysis of industrial risks to recalibrate state-of-the-art vulnerability curves

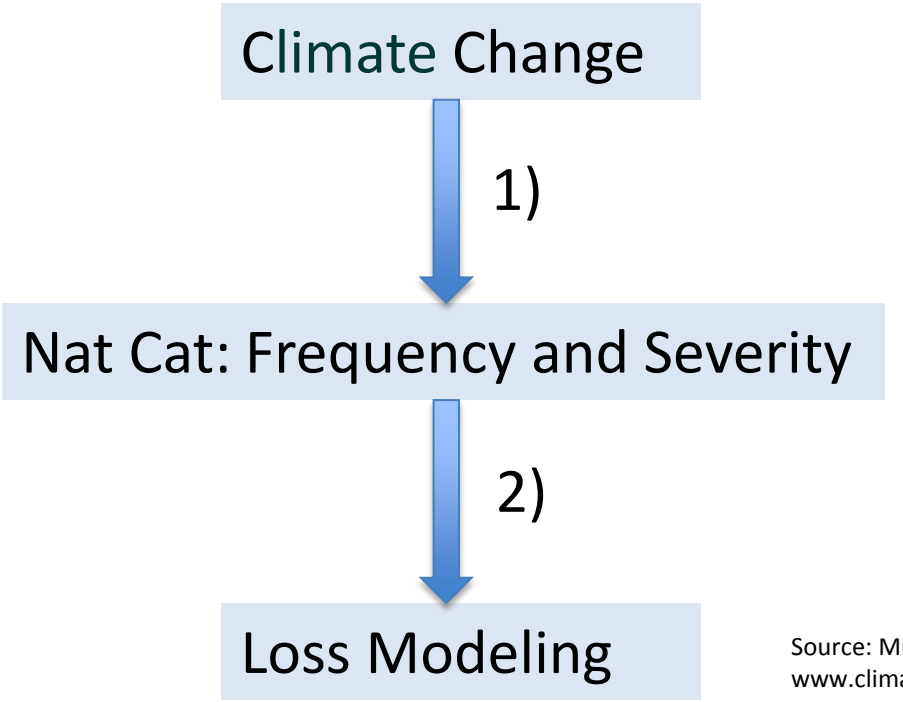
- Analyzed insurance portfolios of Ace Insurance Company for structuring of Catastrophe Bond (Cat Bond) for US HU and US EQ

- Liberty Mutual, AIG, USAA, Farmers, ZFS, Ace Insurance Company, FM Global

Motivation

1) Will climate change alter Nat Cat frequency and severity?

2) Eventually, how much thinner will my wallet be?

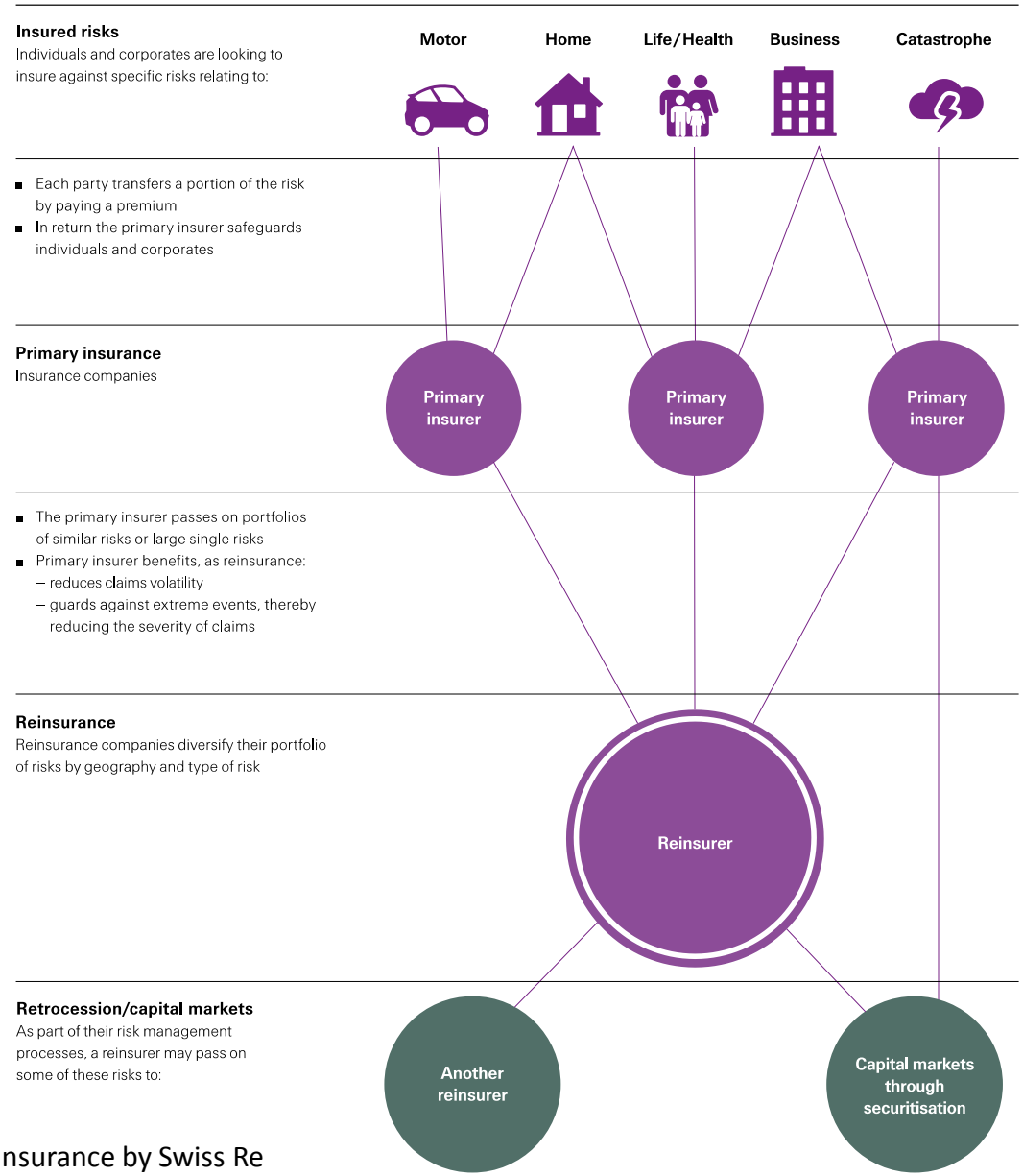


Source: Munich Re
www.climatechangebusinessforum.com/page/file/440/download

How risks are transferred?

Living life and running businesses involve risks. Individuals & companies buy insurance. Insurers buy reinsurance.

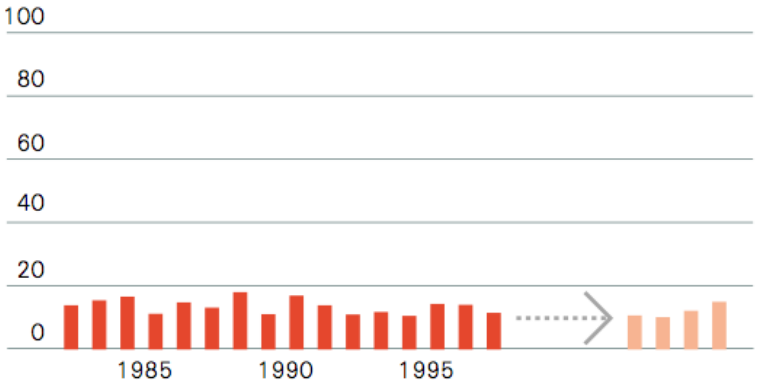
Transfer of risks: Policyholder, Insurance, & Reinsurance



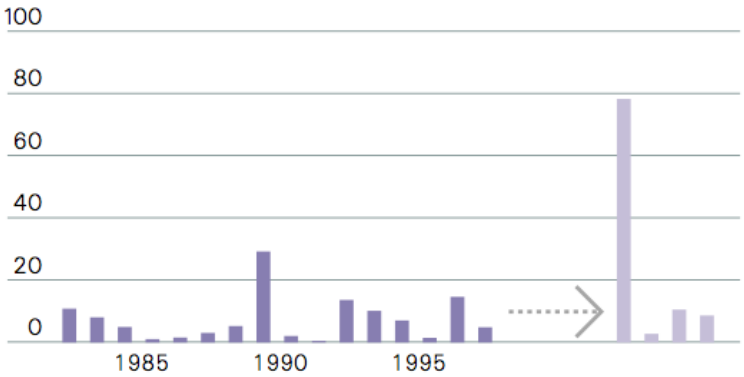
Source: The essential guide to reinsurance by Swiss Re

Why Nat Cat Modeling?

Fire vs Natural Perils



Annual losses caused by fire



Annual losses caused by natural hazards

- Fire losses occur relatively frequently (for an entire portfolio), are fairly consistently over time, and can be analyzed using statistical methods
- Natural catastrophes occur rarely, and their losses fluctuate radically (no losses for decades and suddenly a year of enormous loss, *Katrina 2005*)
- Natural perils loss data is not representative for statistical analysis

→ need for scientific risk assessment

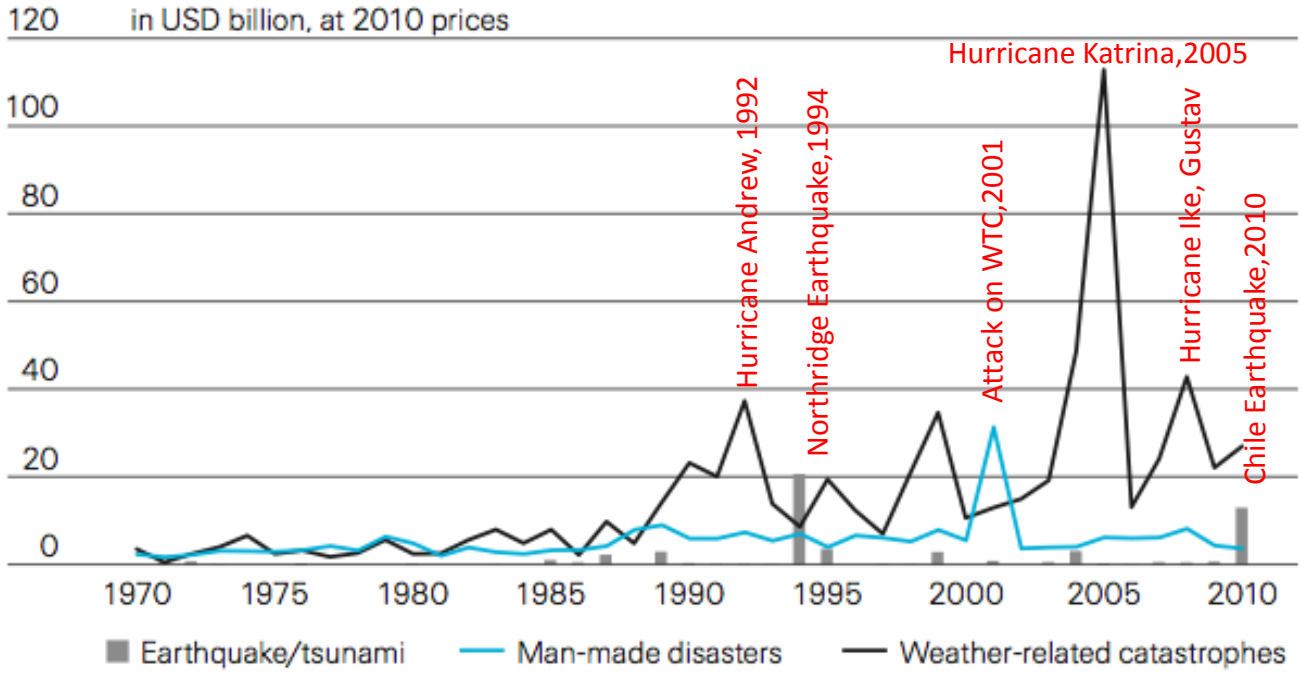
Insured Catastrophe Losses 1970 - 2010

Increasing values

Concentration in exposed areas

Insurance penetration

Changing hazard
- Climate variability
- Climate change



Source: Swiss Re Economic Research & Consulting

Concentration in Exposed Areas

Ocean Drive, FL, 1926

Ocean Drive, FL, 2010

Population Growth Rate: 1930-2010

All US	150%
Florida	1180%

Origins of Nat Cat Modeling

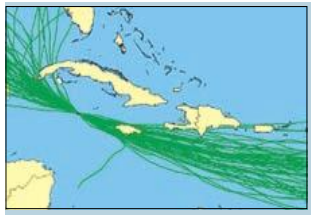
- In 1800s, residential insurers covering fire risk used pins on a wall-hung map to visualize concentrations of exposure; the practice ended in 1960s
- Computer-based probabilistic catastrophe risk modeling started in the late 1980s

- Wide acceptance of Nat Cat models by re/insurance companies after unprecedented losses resulting from hurricane Andrew in 1992
- 3 major Nat Cat Modeling Companies:

RMS® AIR WORLDWIDE EQECAT AN ABS GROUP COMPANY

Probabilistic Hazard Modeling: 4 Box Principle

Natural Hazard

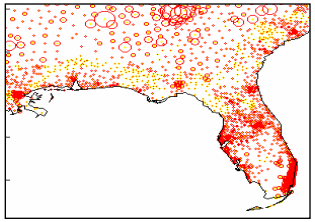


Where, how often, and with intensity do events occur?

Vulnerability

What is the extent of damage at a given intensity?

Value Distribution



Where are insured properties located and how high is their value?

Insurance Conditions

What portion is loss insured and what is deductible?

Where, how often, and how severe?

Natural Hazard

Vulnerability

Value Distribution

Insurance Conditions

Parameters that define Exposure to natural hazard risks:

- Geographical distribution (*FL HU, CA EQ*)
- Occurrence frequency (*1 in 100 years*)
- Intensity (*MMI* for EQ, *wind speed* for HU)

Event Set:

- Historical event catalogues and scientific research are used to quantify above parameters
- Simulate all possible events that could unfold over thousands or tens of thousands of years
- Model produces a "representative" list of event losses

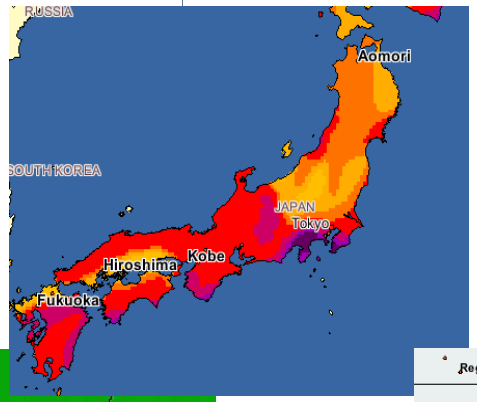
Intensity Measure

Natural Hazard

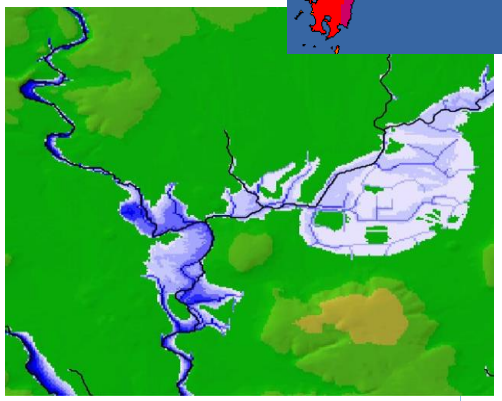
Vulnerability

Value Distribution

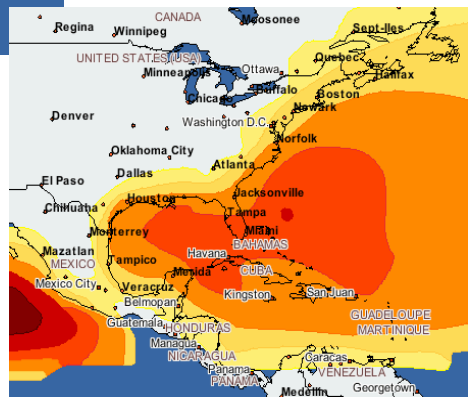
Insurance Conditions



Earthquake: MMI
Modified Mercalli Intensity



Flood:
Water Depth (m)



Atmospheric Perils:
Wind Speed (m/s)

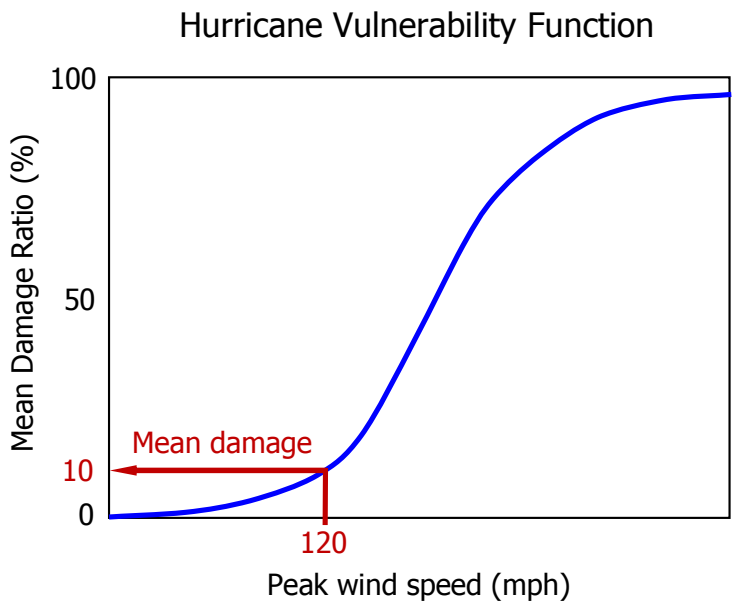
Vulnerability Curve: How extensive will the damage be?

Natural Hazard

Vulnerability

Value Distribution

Insurance Conditions



Building Value = $200,000

MDR = 10% @120mph

Loss = $20,000

A building's vulnerability at a given hazard intensity is measured by its mean damage ratio.

$$\text{MDR} = \frac{\text{average loss}}{\text{replacement value}}$$

Vulnerability curves = f (building characteristics, coverage)

Natural Hazard

Vulnerability

Value Distribution

Insurance Conditions

- **Occupancy Type:** residential, commercial, industrial
- **Construction Class:** Wood frame, masonry, reinforced concrete, steel, mobile home
- **Building Height:** 3 story RCC vs 15 story RCC
- **Year of Construction:** 1980 vs 2012 (building code)
- **Insurance Coverage:** Building, Contents, Business Interruption

Exposure Data and Geocoding

Natural Hazard

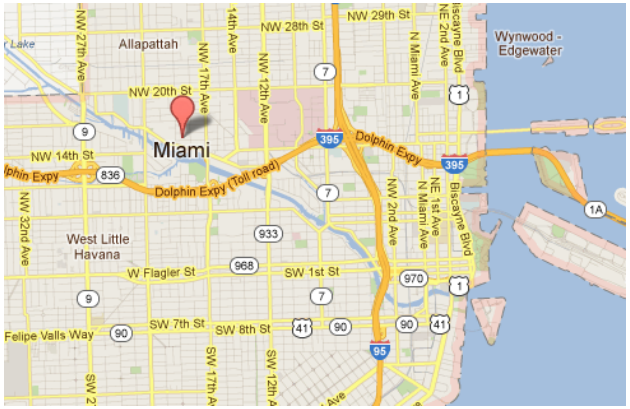
Vulnerability

Value Distribution

Insurance Conditions

Exposure Data:

- Total Insured Value of assets that is at risk
- Construction, occupancy, height, year built
- Address
- Perils to be modeled



Geocoding:

- Process of finding Lat/Lon
- Risk is at coast or inland (how far)
- Higher the geocoding resolution, more precise the loss numbers

Deductibles & Policy Limit

Natural Hazard

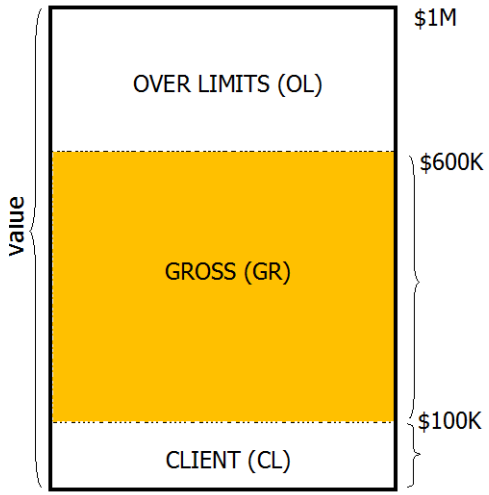
Vulnerability

Value Distribution

Insurance Conditions

Deductible:

- Share of loss among policyholder, insurer, and reinsurer
- Cap the amount the re/insurer is liable to pay
- Reduce the re/insurer's administrative burden
- Can be number of days for Business Interruption



Value: Full replacement cost of risk

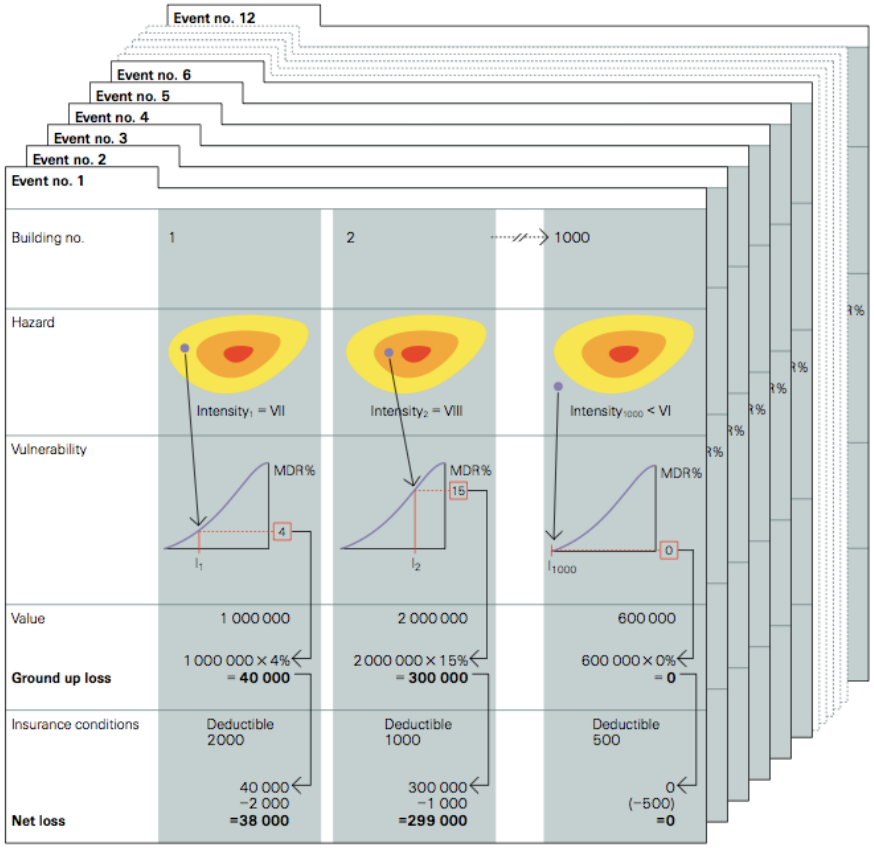
Limit: Max amount covered by insurer

Deductible: Amount not covered by insurance policy (always takes loss first)

Value	$1,000,000
Deductible	$100,000
Limit	$500,000

Loss Modeling Process

- 1000 insured buildings
- Total sum insured = $1000 million
- EQ prone region
- 12 over a projected period of 200 years



Event loss

No. 1 =	(38 000	+	299 000	+	... ...	+	... ...	+	0)	=	23.5 m
No. 2 =	(0	+	25 000	+	... ...	+	... ...	+	54 000)	=	42.5 m
No. 3 =	(75 000	+	36 000	+	... ...	+	15 000	+	0)	=	74.8 m
No. 4 =	(0	+	0	+	... ...	+	... ...	+	63 000)	=	8.9 m
No. 5 =	(... ...	+	... ...	+	... ...	+	... ...	+	... ...)	=	13.1 m
No. 6 =	(... ...	+	... ...	+	... ...	+	... ...	+	... ...)	=	69.6 m
No. 12 =	(0	+	0	+	... ...	+	... ...	+	63 000)	=	58.6 m

Source: Natural Catastrophes and Reinsurance by Swiss Re

Output: Loss Frequency Curve

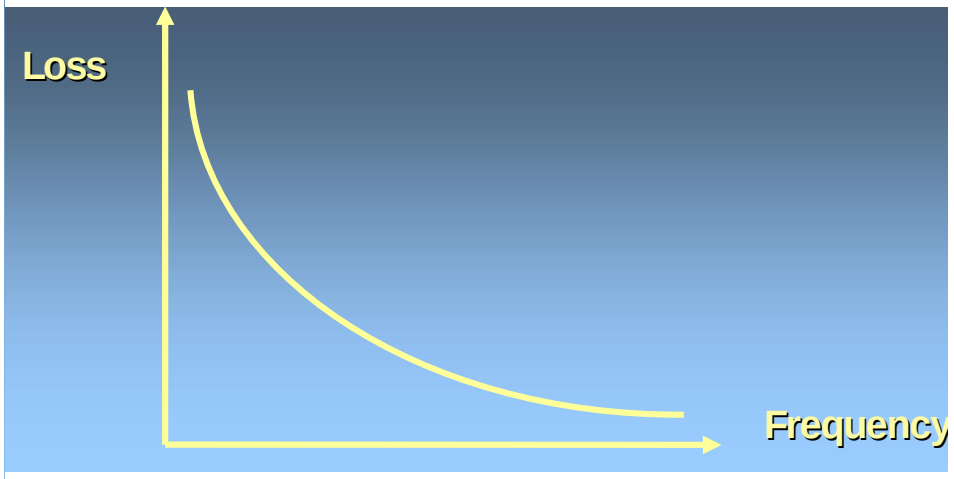
Natural Hazard

Vulnerability

Value Distribution

Insurance Conditions

Combine



Can we trust Nat Cat Models?

- A model is nothing more than a simplified representation of reality

- **Yes if**
  - models are calibrated (many times sufficient data is not available)
  - used within their limits
  - exposure data has sufficient detail and is of high quality
  - Un-modeled perils are properly considered
  - Aware of risks beyond the model parameter

Disproportionate changes in extremes in comparison to changes in mean climate conditions

Hazard	Cause of Change in Hazard	Resulting Change in Damage/Loss
Windstorm	Doubling of wind speed	Four-fold increase in damages
	2.2 °C mean temperature increase	Increase of 5-10% hurricane wind speed
Extreme temp	1 °C mean temperature increase	300-year temperature events occur every 10 years
Flooding	25% increase in 30 minute precipitation	Flooding return period reduced from 100 years to 17 years
Bushfire	1 °C mean summer temperature increase	17—28% increase wildfires
	Doubling of CO_2	143%increase in catastrophic wildfires

Mills E, Lecomte E, Peara A., US Insurance Industry Perspectives on Climate Change, Feb 2001, US Dept of Energy

Summary

Source: Munich Re
www.climatechangebusinessforum.com/page/file/440/download

1) Will climate change alter Nat Cat frequency and severity

2) Eventually, how much thinner will my wallet be?

Climate Change

1) Almost certain for many perils

Nat Cat: Frequency and Severity

2) Nonlinear

Loss Modeling

Economic loss can significantly outpace climate change

Insurance loss can increase even more


THANK
YOU

The [property/casualty] industry is at great risk if it does not understand global climate variability and the frequency of extreme events.

-Franklin Nutter, President, Reinsurance Association of America (1999)