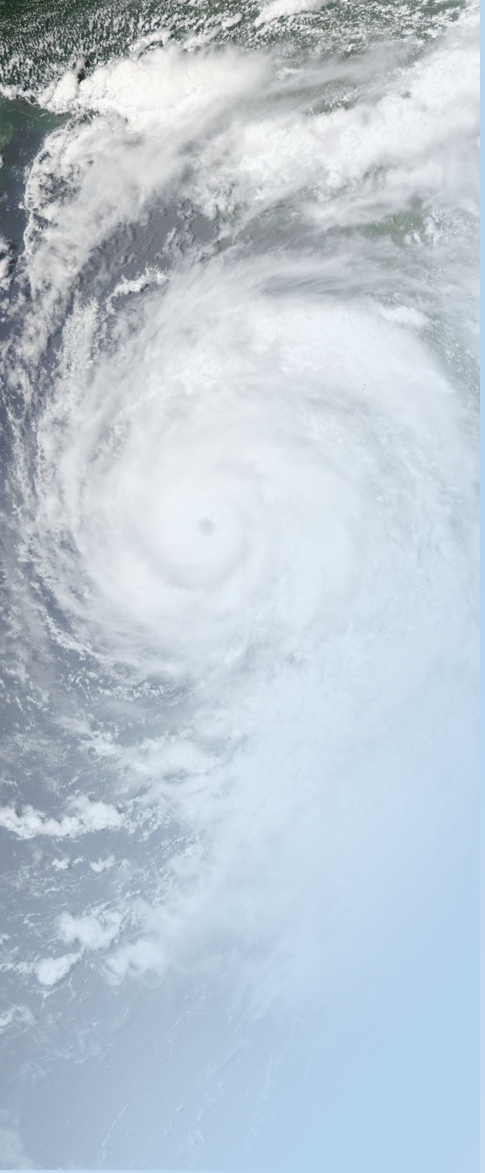
ISCM Education Seminar: Catastrophe Modeling



An Overview of Today's Seminar

Hazard
Event Generation

Where?
How Big?
How Often?

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

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

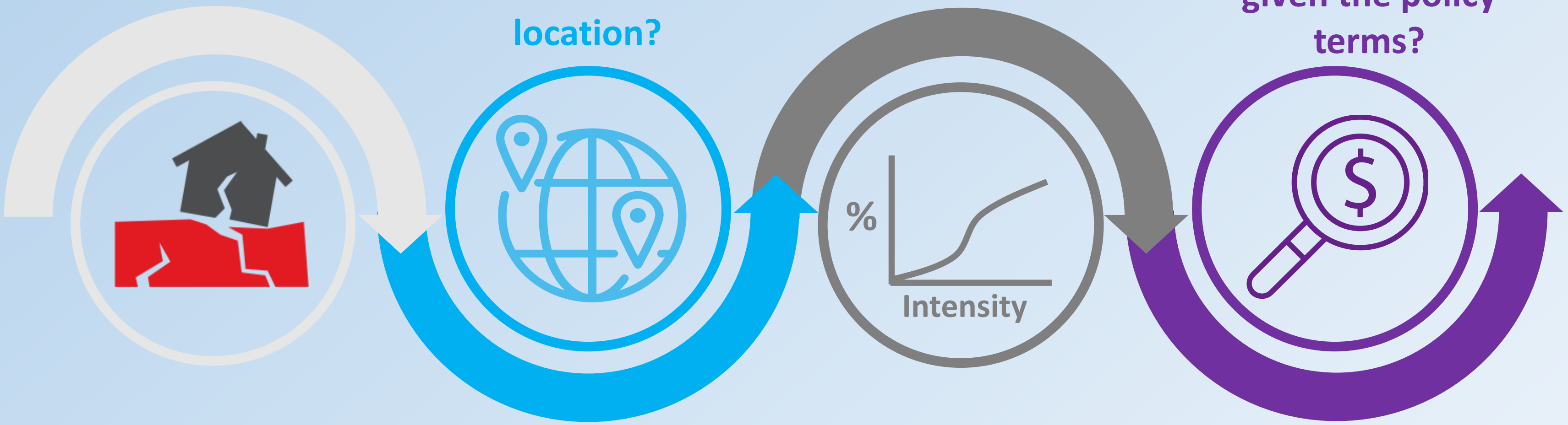
What is the damage to a location?

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

Financial
Insured Loss Calculation

How does the damage get paid given the policy terms?

- Consider:
  - Limits
  - Deductibles
  - Reinsurance



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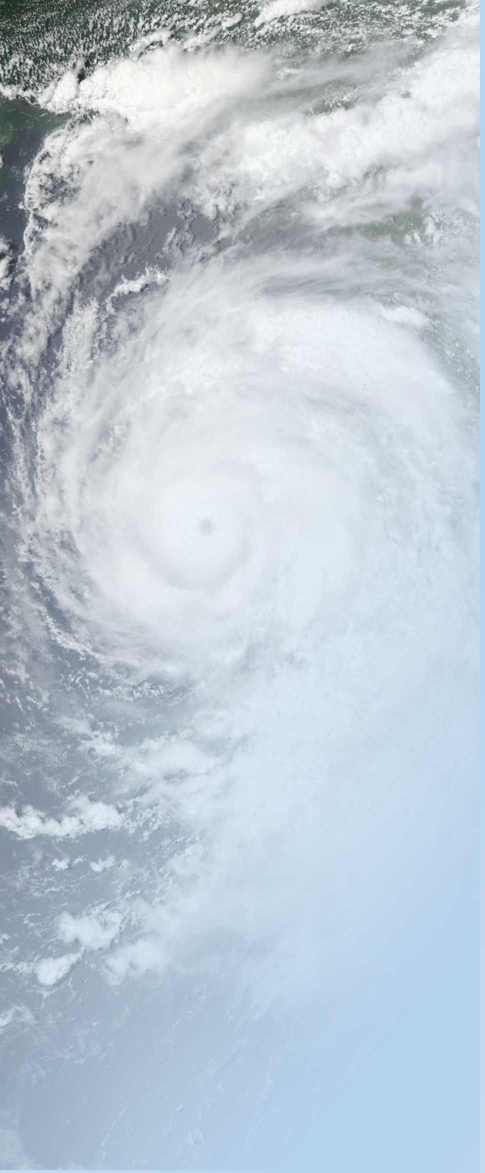

Detailed Agenda

9:00am	Introduction/Overview
9:15am	Hazard Modules (SCS, by sub-peril) - Veronica McNear
10:00am	**Networking Break**
10:15am	Advanced Catastrophe Model Vulnerability - Anna Milliken
11:00am	**Networking Break**
11:15pm	Advanced Concepts in Financial Modeling - Susan Denike
12:00pm	**Networking Break / Lunch Setup**
12:30pm	Round Table Discussion
1:30pm	ISCM/iCAS Update and Discussion - Minchong Mao
2:00pm	Guest Speaker: Dr. Victor Gensini - Updates in Tornado Research
3:00pm	**Networking Break**
3:15pm	Guest Speaker: Julie Serakos - Practical Applications of Catastrophe Modeling
4:15pm	Q&A and Wrap-Up
4:30pm	Networking Event

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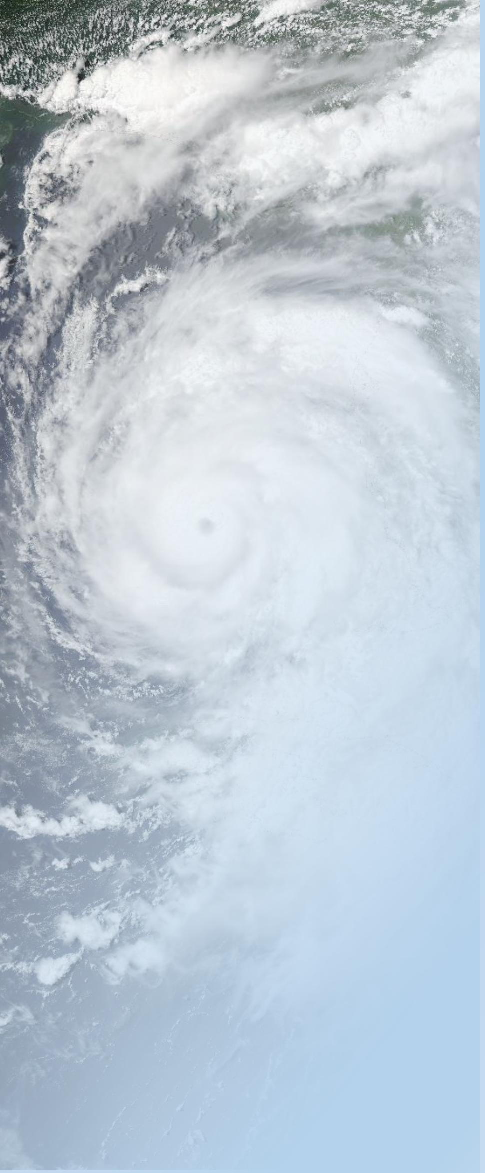
Catastrophe Modeling

A Brief History and Introduction

Dan Dick, Aon Benfield



Why Catastrophe Models?

- Need to manage cat risk
- Stakeholders and regulators need a means to quantify potential loss
- Loss experience does not provide enough data points to stand by itself as a view of catastrophic risk exposure / loss estimation

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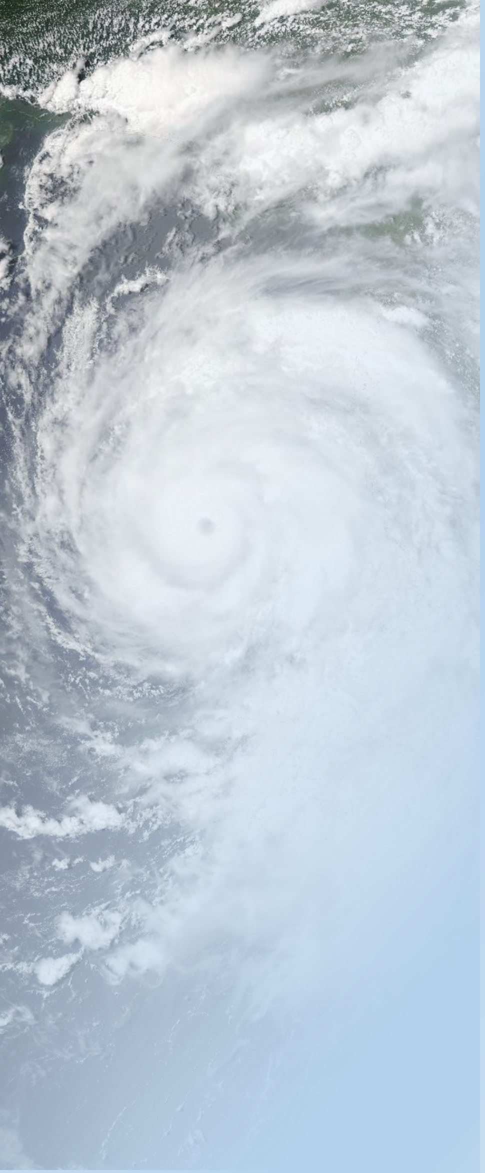
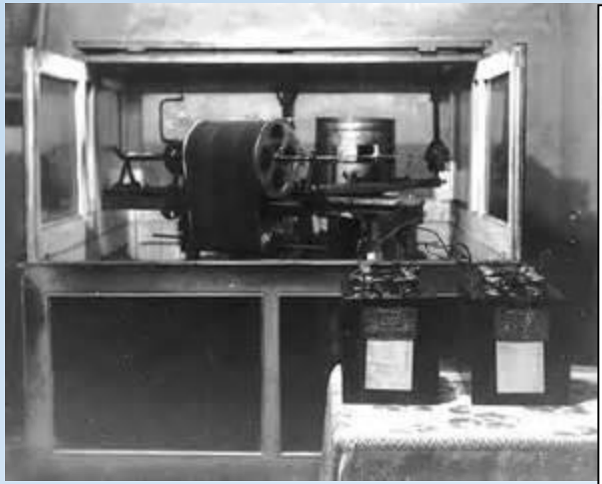
Early Exposure Management



Early Understanding of the Hazard

Measurement:

- 1800’s – the first modern seismograph
    - 1930’s Richter scale
- 1840’s – hemispheric cup anemometer
    - 1971 Saffir-Simpson scale



Hazard:

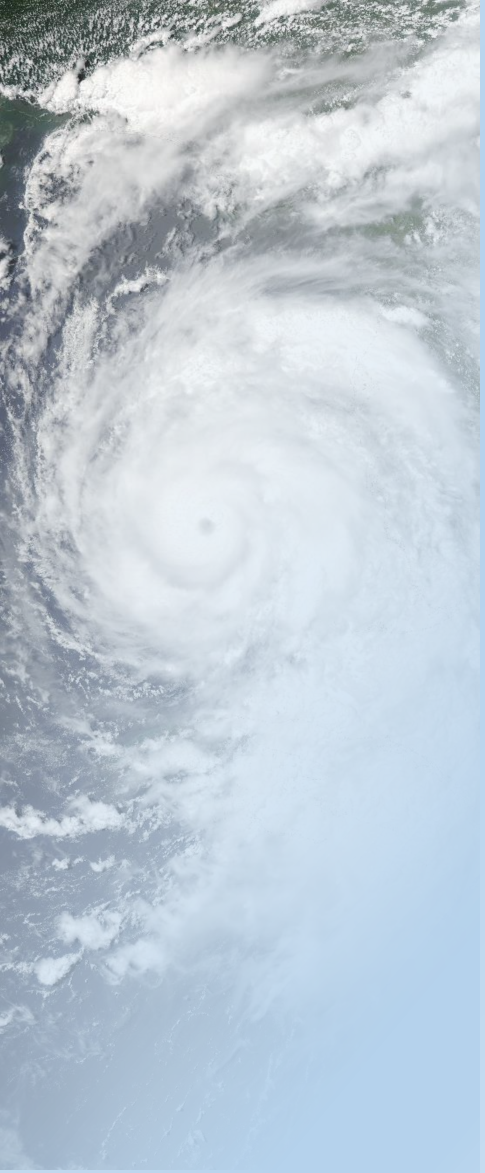
- U.S. Water Resource Council (1967, flood)
- S. T. Algermissen (1969, earthquake)
- NOAA (1972, hurricane forecasts)
- Waltraud Brinkmann (1975, hurricane hazards)
- Karl Steinbrugge (1982, earthquake, volcanoes, and tsuanmis)

Key US earthquakes:

- 1933 Long Beach California
- 1964 Alaska (9.2)
- 1971 San Fernando Valley

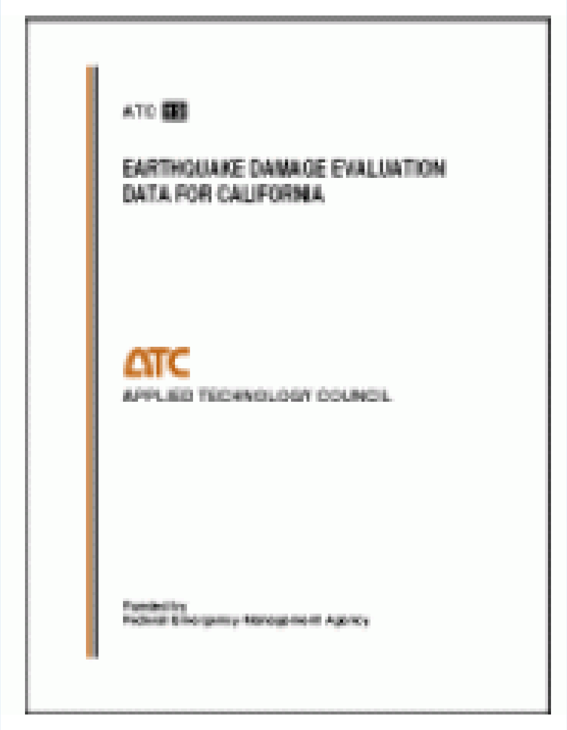
Key US hurricanes:

- Hurricane Camille (1969)



Harnessing the Power of Computers

- Late 1980's computing power brought together the mapping of risk and the measurement of hazard
- Spawned multiple modeling firms:
  - 1987 Applied Insurance Research
  - 1988 Risk Management Solutions
  - 1994 EQECAT (now part of CoreLogic)
  - 1994 Impact Forecasting
  - and many more in the last 3 to 5 years



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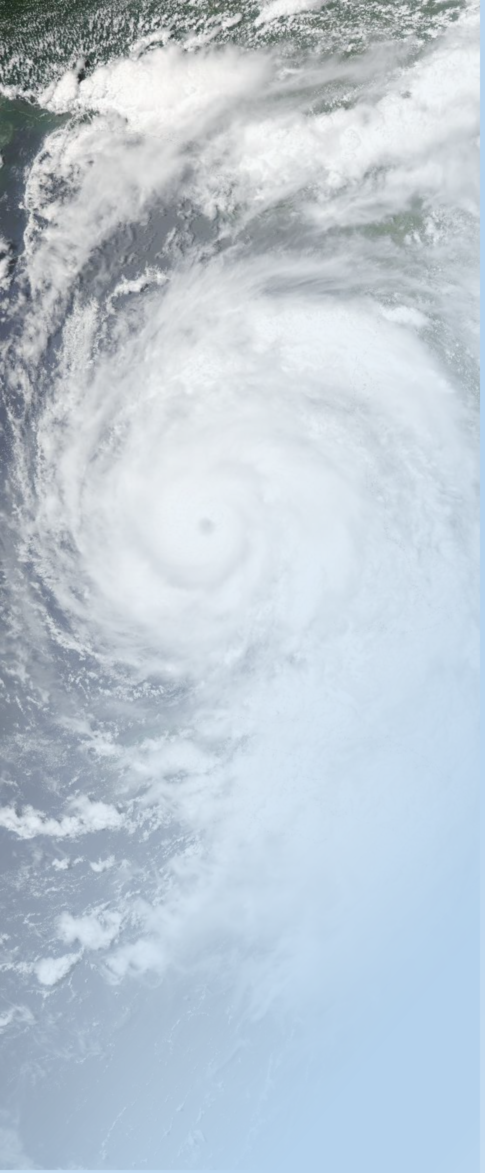

Key Events Increased Demand for Cat Models

- September 21, 1989 – Hurricane Hugo (South Carolina)
- October 17, 1989 – Loma Prieta Earthquake (San Francisco)
- August 24, 1992 – Hurricane Andrew (Homestead, FL, Morgan City, LA)
  - Nine insurers became insolvent
- January 17, 1994 – Northridge Earthquake (Northridge, CA)
- Andrew created a new “wave” of (re)insurers, all heavily reliant on catastrophe models
- Additional (re)insurers were started after 9/11 and the 2004/05 hurricane seasons
- Hurricane Ike (2008)
- 2011 tornado outbreaks (Joplin, Tuscaloosa)
- Superstorm Sandy (2012)
- Harvey, Irma, Maria, California Fires (2017)

Today, Models Exist for Many Perils

- Hurricane
- Storm Surge
- Severe Convective Storm (Tornadoes, Hail, Straight-line Winds)
- Earthquake
- Fire Following Earthquake
- Terrorism
- River Flood
- Flash Flood (Rainfall Induced)
- Brush Fire
- Winter Storm
- Cyber

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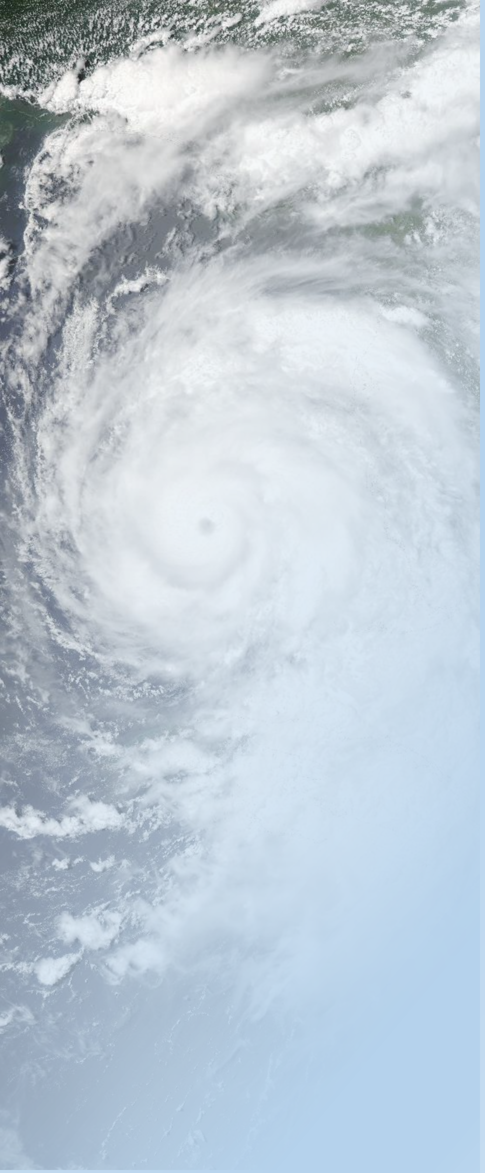
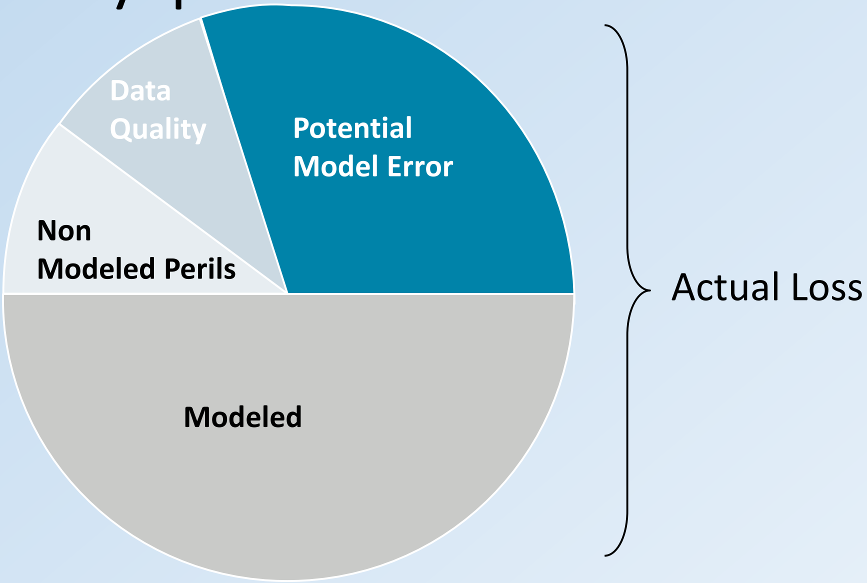


But models are still not fully predictive



- Non-Modeled Perils / Coverages
  - Contingent BI
  - Flood, Sewer Backup
  - LAE
  - Auto, Boats, Cargo
  - Government Mandates
  - Wind Pool Assessments
  - Extra contractual liability
  - Mold damage, foundation collapse due to beach erosion, etc.

- Data Quality
  - Address Match
  - ITV
  - Incorrect Data
  - Missing Locations
  - 5 Primary Characteristics

- Potential Model Error
  - Vulnerability
  - Severity
  - Frequency
  - Demand Surge
  - Insurance Recovery Calculations

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Severe Thunderstorm Modeling

ICSM Education Seminar

September 13, 2018

Why do we care About Severe Thunderstorm Risk?

Top 5 Global Risks in Terms of Likelihood

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1st	Asset price collapse	Asset price collapse	Asset price collapse	Storms and cyclones	Severe income disparity	Severe income disparity	Income disparity	Interstate conflict with regional consequences	Large-scale involuntary migration	Extreme weather events	Extreme weather events
2nd	Middle East instability	Slowing Chinese economy (<6%)	Slowing Chinese economy (<6%)	Flooding	Chronic fiscal imbalances	Chronic fiscal imbalances	Extreme weather events	Extreme weather events	Extreme weather events	Large-scale involuntary migration	Natural disasters
3rd	Failed and failing states	Chronic disease	Chronic disease	Corruption	Rising greenhouse gas emissions	Rising greenhouse gas emissions	Unemployment and underemployment	Failure of national governance	Failure of climate-change mitigation and adaptation	Major natural disasters	Cyberattacks
4th	Oil and gas price spike	Global governance gaps	Fiscal crises	Biodiversity loss	Cyber attacks	Water supply crises	Climate change	State collapse or crisis	Interstate conflict with regional consequences	Large-scale terrorist attacks	Data fraud or theft
5th	Chronic disease, developed world	Retrenchment from globalization (emerging)	Global governance gaps	Climate change	Water supply crises	Mismanagement of population ageing	Cyber attacks	High structural unemployment or underemployment	Major natural catastrophes	Massive incident of data fraud/theft	Failure of climate-change mitigation and adaptation

Economic Environmental Geopolitical Societal Technological

2017 World Economic Forum Global Risks Report

Increasing acknowledgement by many policy groups that globally we are witnessing an increase in cat events and extreme weather

1 Ingredients of a Severe Thunderstorm

Mid Latitude Lows

STRIKING THE MATCH THAT SPARKS SEVERE WEATHER

“Severe” Thunderstorm: must produce one of the following

- A tornado
- Hail at least one inch in diameter (about quarter-sized)
- Straight line winds in excess of 50 knots (57.5 mph)

Three Ingredients for Major Severe Thunderstorm Outbreak

1. Thick layer of warm, moist air in the lower troposphere
2. A “steep” unstable lapse rate with sufficiently cold air aloft to ensure that parcels of moist air can ascend to great latitudes
3. Strong lifting by a low-pressure system and its attendant upper-level trough or its associate fronts

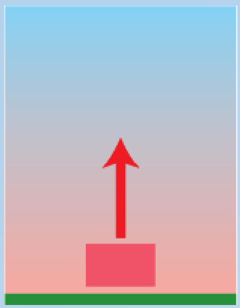
In other words….

1. Instability
2. Lifting mechanism

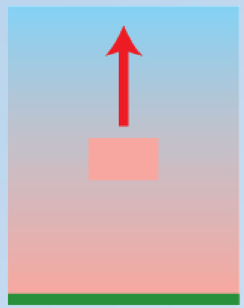
Finding Instability

DENSITY DIFFERENCES

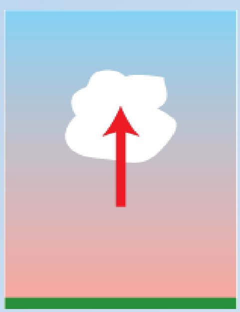
- Warm, moist air is less dense than cold dry air
- Air parcels cool as they rise (pressure decreases so the parcel expands)



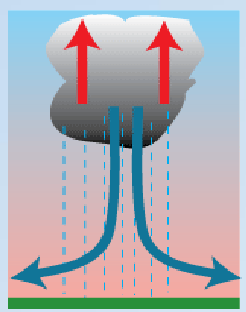
1. Air, warmed by the ground, rises.



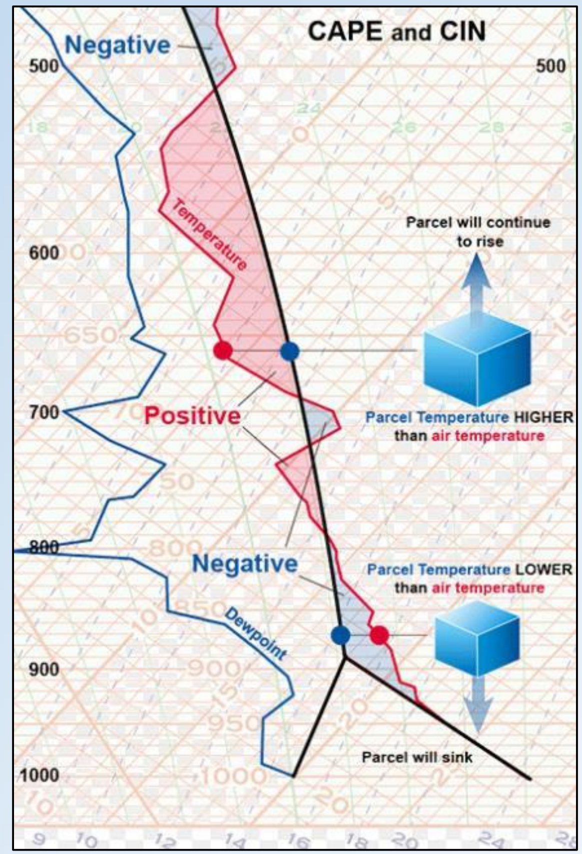
2. As it rises it cools - but it's still warmer than the surrounding air.



3. Water vapour condenses into water droplets: cloud.

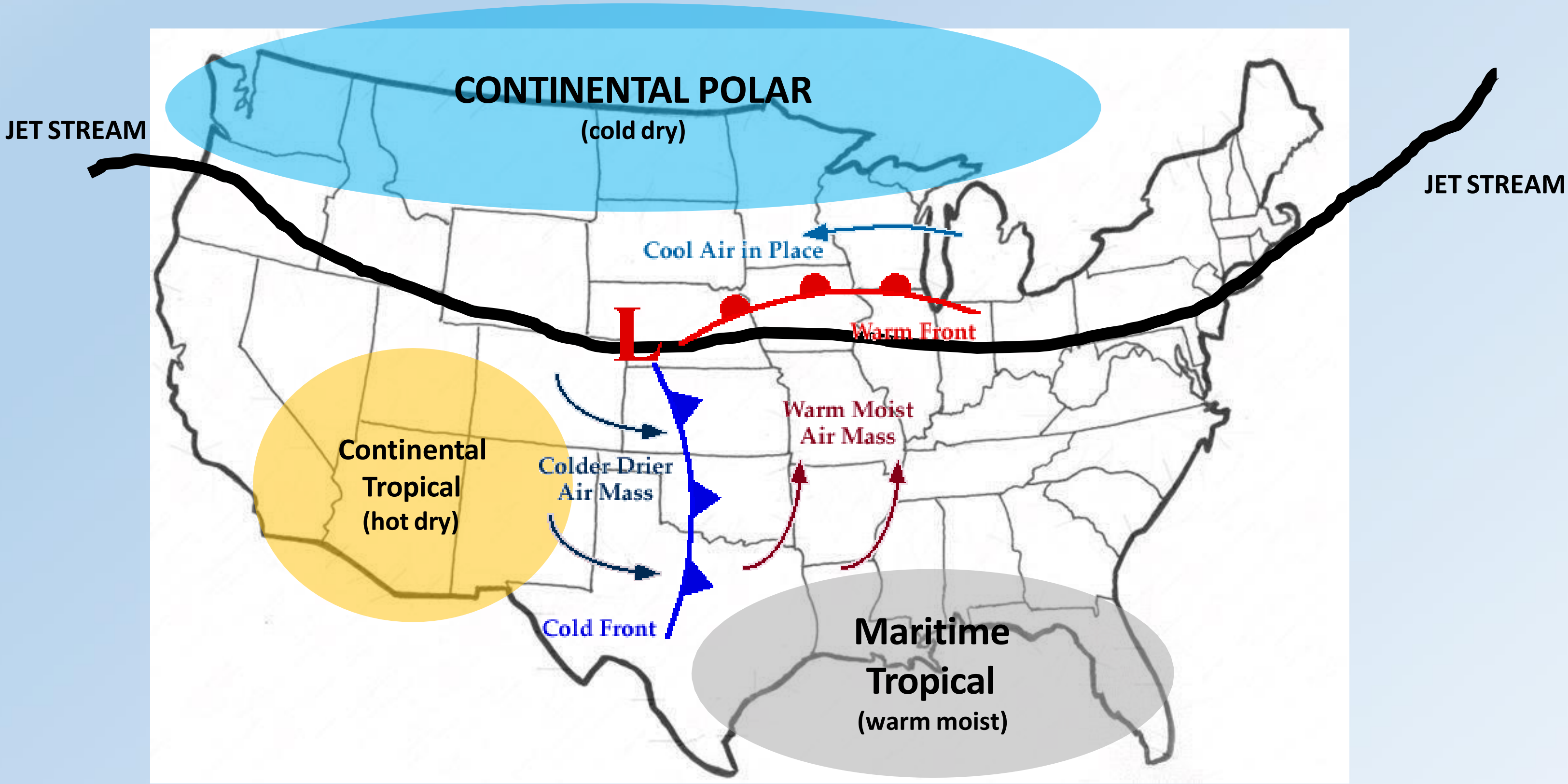


4. Process continues to form rain, and cold (dense) air descends with it.



Central U.S. Ripe For Instability

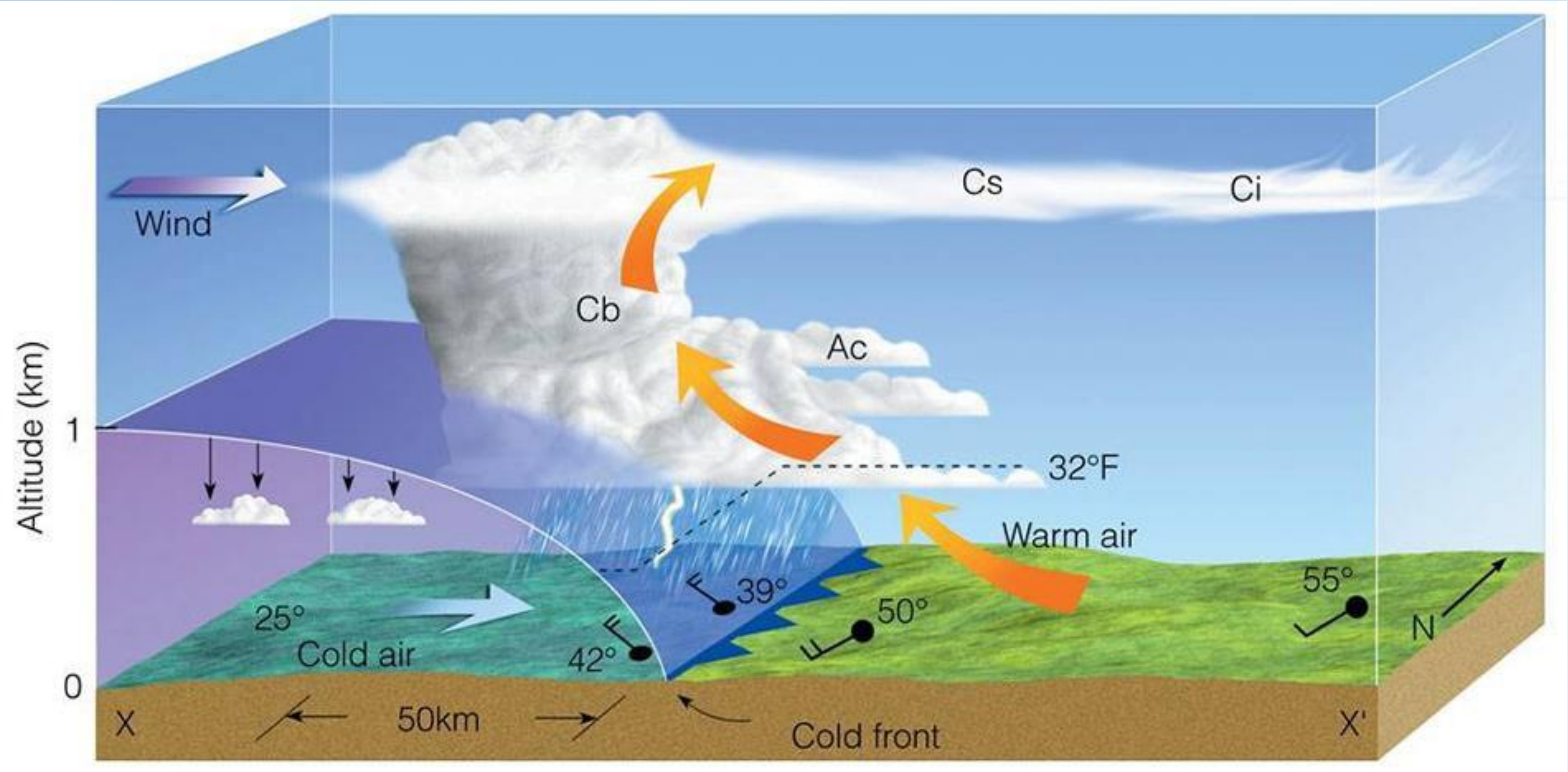
DIFFERENCES IN AIR MASSES



- Central U.S. is a natural breeding ground for instability
- Warm, moist Gulf of Mexico air mass collides with cool, dry air mass
- Low pressure systems riding along jet stream provide lifting mechanism – although this isn't always necessary!

What happens at the front?

INSTABILITY + UPLIFT = THUNDERSTORM



Severe Convective Storms

MODES OF DAMAGE

HAIL

- Hail is an aggregate term in reference to one or more ice particles, or hailstones of
- pea size (approximately 5 millimeters in diameter) or larger that are often produced by vertically developing clouds.

STRAIGHT-LINE-WIND

- Convectively driven winds that occur from a thunderstorm aside from the more well-known tornadoes.

✓ Downbursts

✓ Outflows

✓ Microbursts

✓ Derechos

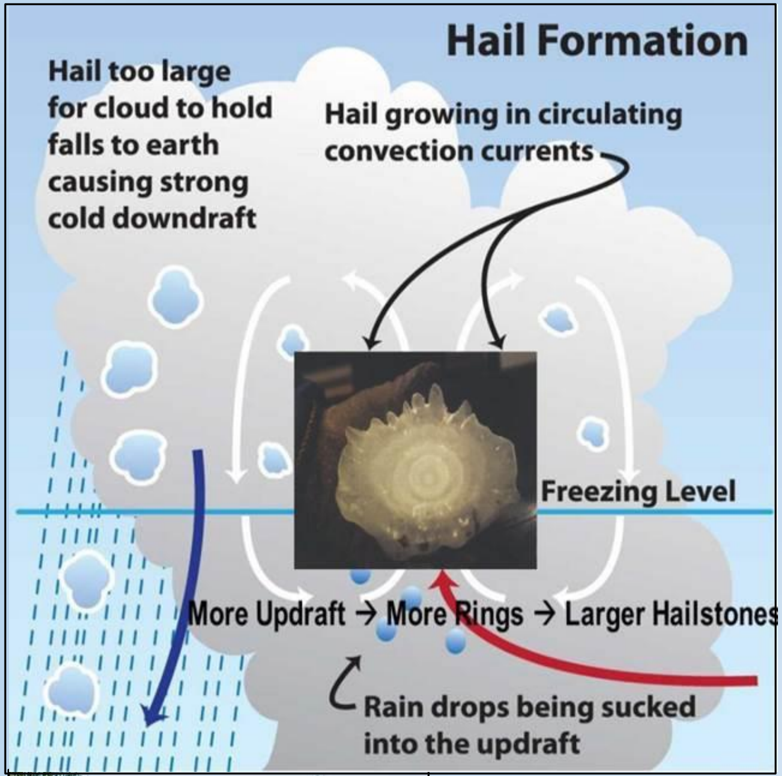
TORNADO

- Rotating column of air, extending upward from the earth's surface to the
- base of a vertically developing cloud that is intense enough at the surface to cause damage

2 Hail

Hail size vs. structural impact

THE SCIENCE



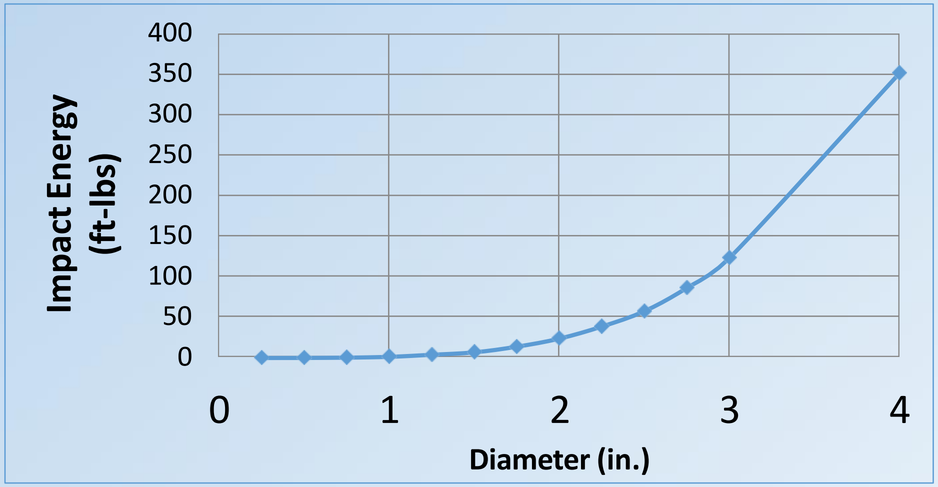


Table 10. TORRO hailstorm intensity scale

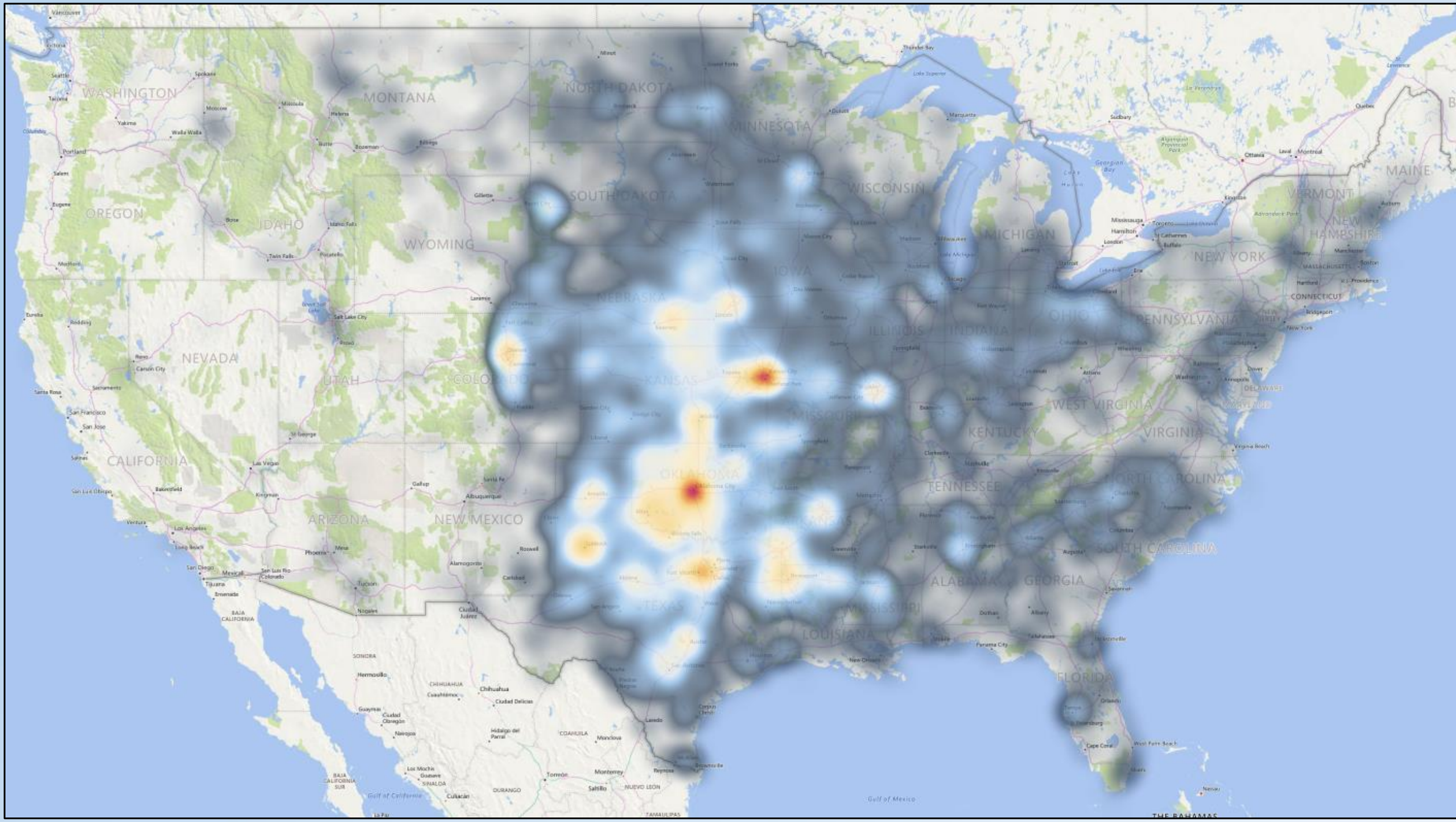
Intensity Category	Typical Hail Diameter (mm)*	Probable Kinetic Energy (J-m^2)	Typical Damage Impacts
H0 Hard Hail	5	0-20	No damage
H1 Potentially Damaging	5-**15**	>20	Slight general damage to plants, crops
H2 Significant	10-**20**	>100	Significant damage to fruit, crops, vegetation
H3 Severe	20-**30**	>300	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
H4 Severe	25-**40**	>500	Widespread glass damage, vehicle bodywork damage
H5 Destructive	30-**50**	>800	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6 Destructive	40-**60**		Bodywork of grounded aircraft dented, brick walls pitted
H7 Destructive	50-**75**		Severe roof damage, risk of serious injuries
H8 Destructive	60-**90**		(Severest recorded in the British Isles) Severe damage to aircraft bodywork
H9 Super Hailstorms	75-**100**		Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
H10 Super Hailstorms	>**100**		Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

*Bold—Typical maximum reported diameter

3.5 to 4" hail in Norfolk, NE
June 3, 2014

Hail Observations

1955 - 2015



- Storm Prediction Center (SPC) hail observations from 1955 – 2015
- Inherent population biases, but still representative of the hail frequency climatology across the central plains

3 Tornadoes

Tornado Conditions & Genesis

IT'S COMPLICATED

- Tornadoes are violently rotating columns of air, usually associated with a swirling cloud of debris or dust near the ground and a funnel-shaped cloud extending downward from the base of the parent cumulonimbus updraft.

- Two formation scenarios:

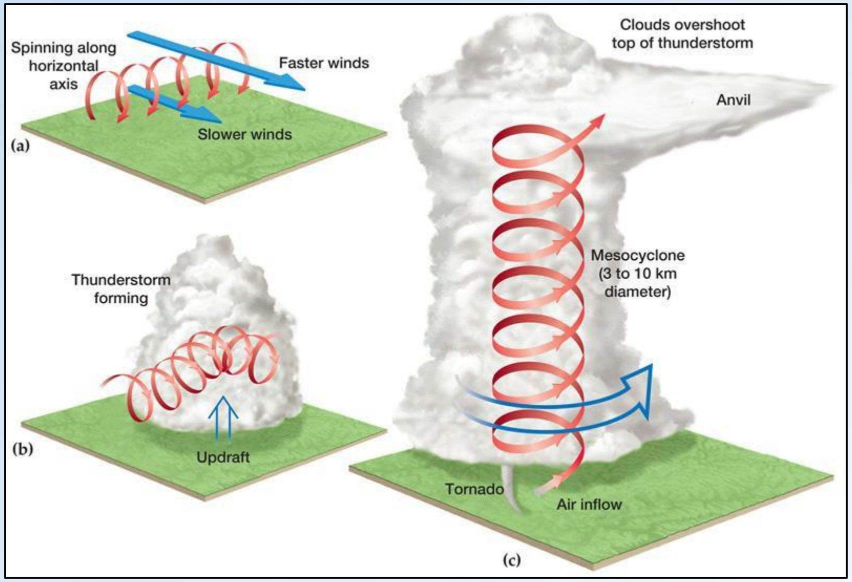
  1. Pre-existing vertical rotation (vorticity) near the ground
  2. Tilting of horizontal rotation (vorticity) supplemented by the downdraft

- **General Conditions:**

  1. Most strong (EF2 –EF3) and virtually all violent (EF4 – EF5) tornadoes are associated with supercells

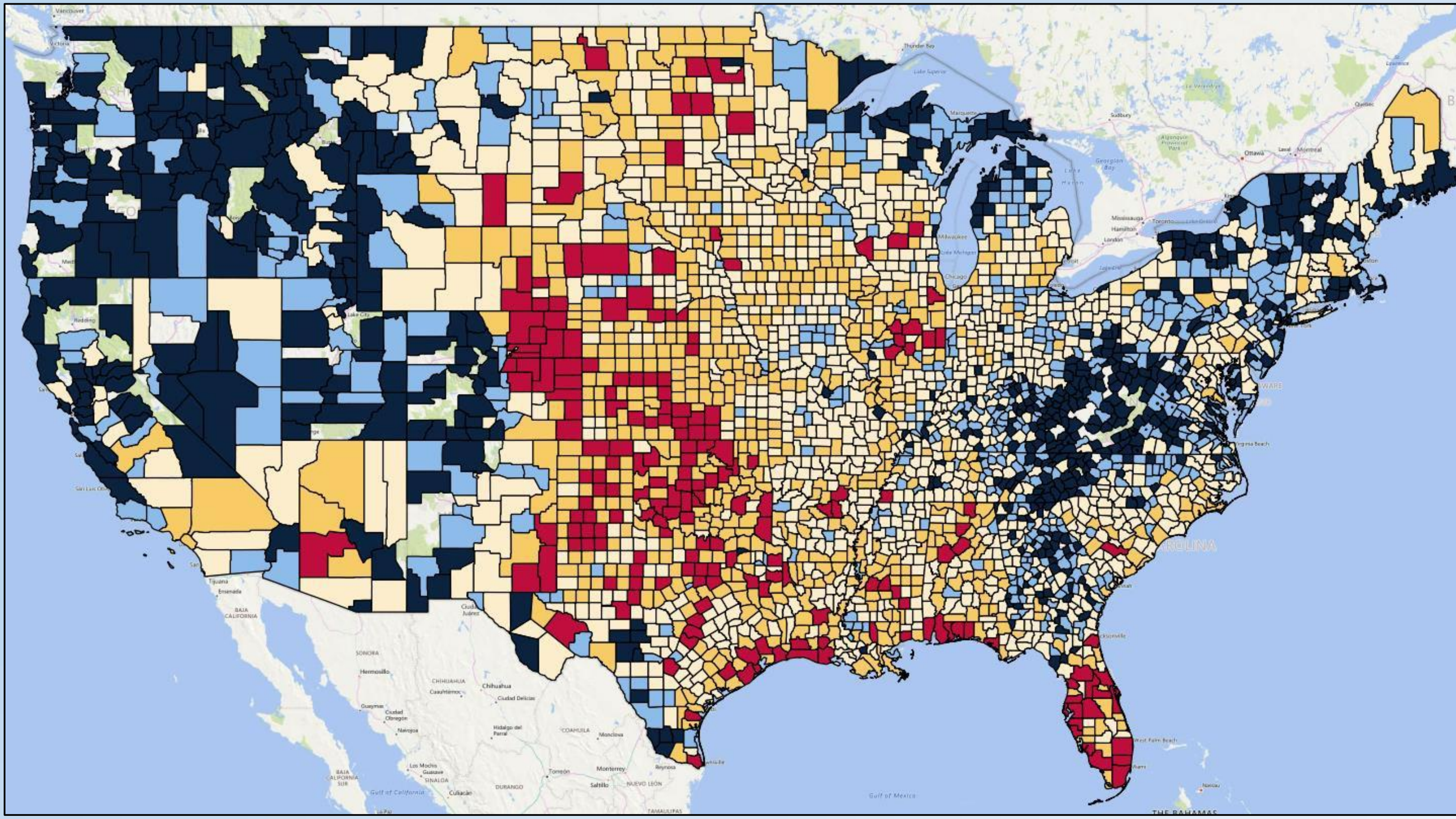
  2. Supercells require an appropriate amount of wind shear and CAPE to produce tornadoes

  3. A lower altitude Lifting Condensation Level (LCL) and low level wind shear



Tornado Count by County

1950 - 2015

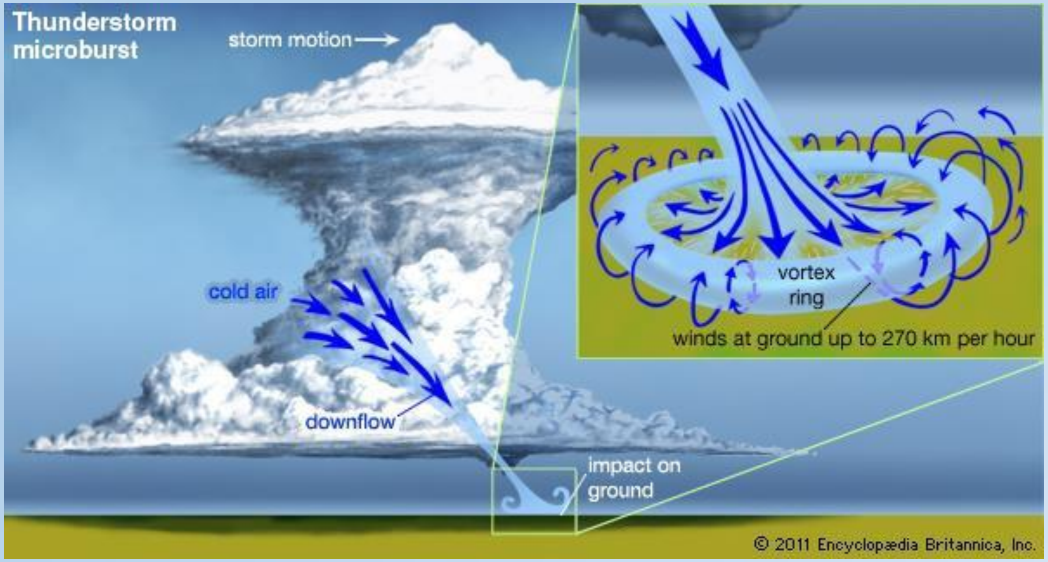


- Storm Prediction Center (SPC) tornado observations from 1950 – 2015
- Inherent population biases, but still representative of the tornado frequency climatology across the U.S.

4 Straight-Line Wind

Derechos & Microbursts

COMMON STRAIGHT-LINE WIND EXAMPLES

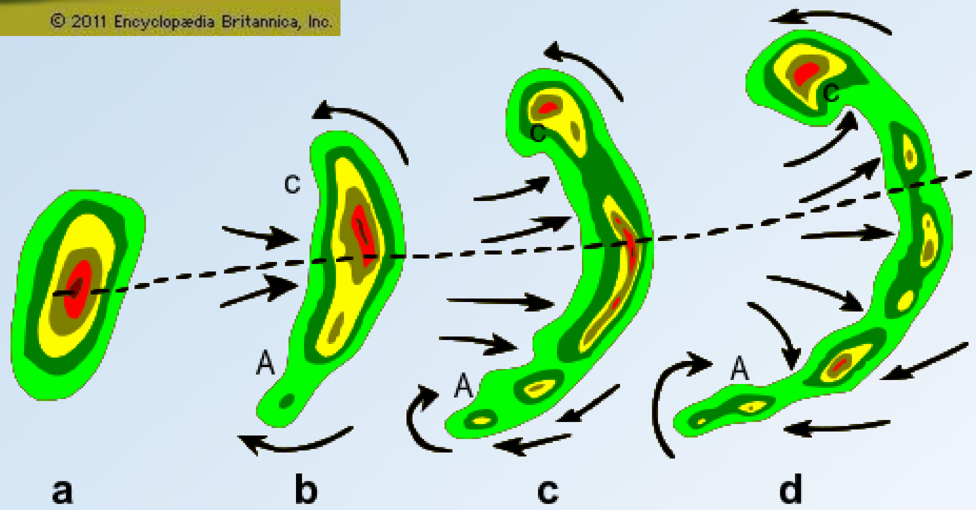


Downbursts are produced by a downdraft (by definition) and are associated with relatively high pressure at the surface which deflects downward-directed streamlines horizontally.

If the downburst is particularly small, it is known as a microburst.

Typical evolution of (a) into a bow echo (b, c) and into a comma echo (d). Dashed line indicates axis of greatest potential for downbursts.

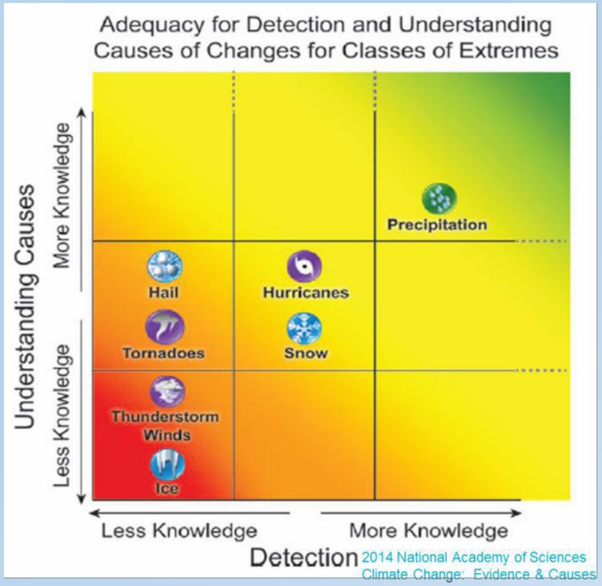
Arrows indicate wind flow relative to the storm. Area C is most prone to supporting tornado development.

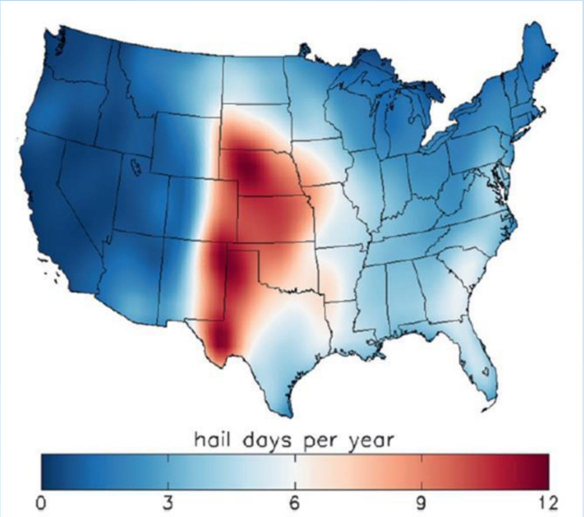


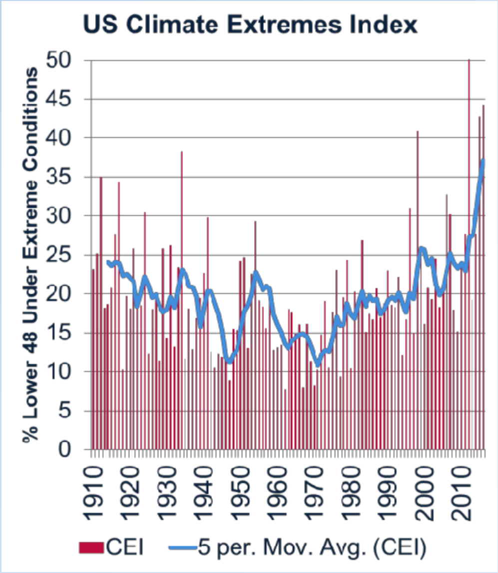
5 Severe convective storm modeling fundamentals

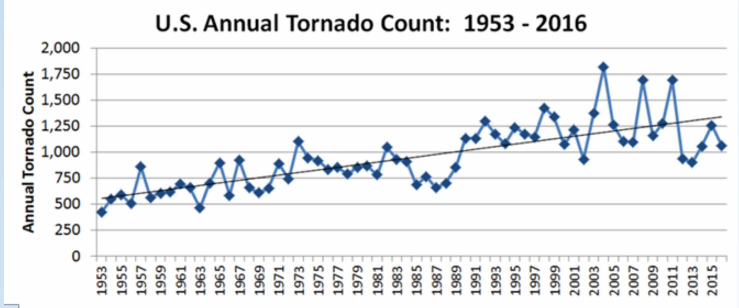
Why Do We Care About Modeling SCS?

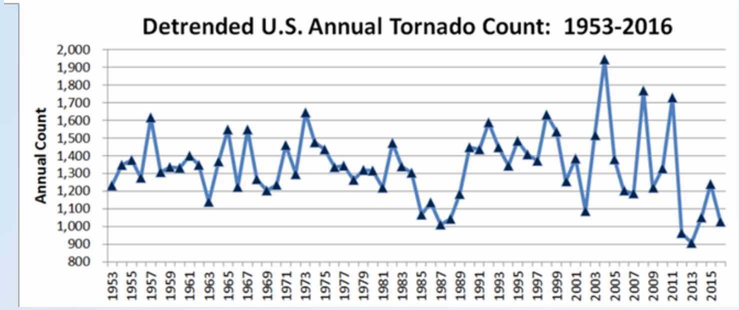
MORE VOLATILITY IN WEATHER PATTERNS











Why Do We Care About Modeling SCS?

CAT MODELING BEST PRACTICES

1) Ensuring adequate pricing commensurate with risk profile

2) Harnessing incurred losses to drive insights into business

3) Effectively using catastrophe analytics to optimize reinsurance strategy

4) Positioning favorably with external stakeholders

Ingredients of a Cat Model

SEVERE CONVECTIVE STORM

Stochastic Event Module

Define

Frequency/Rate

Number and size of hail, tornado and wind streaks

Location and orientation of each tornado, hail and wind streak

Hazard Module

Assess

Hazard intensity at each location

Surface roughness

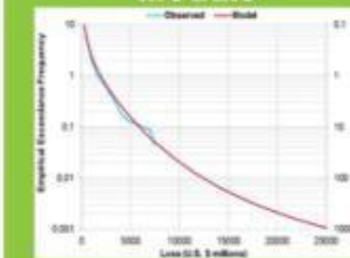
Vulnerability Module

Calculate

Vulnerability

Mean Damage Ratio (MDR) and Coefficient of Variation (CV)

Financial Analysis Module



Quantify

Losses to different financial perspectives

Event Set Generation

HOW DO YOU DEFINE AN SCS EVENT?

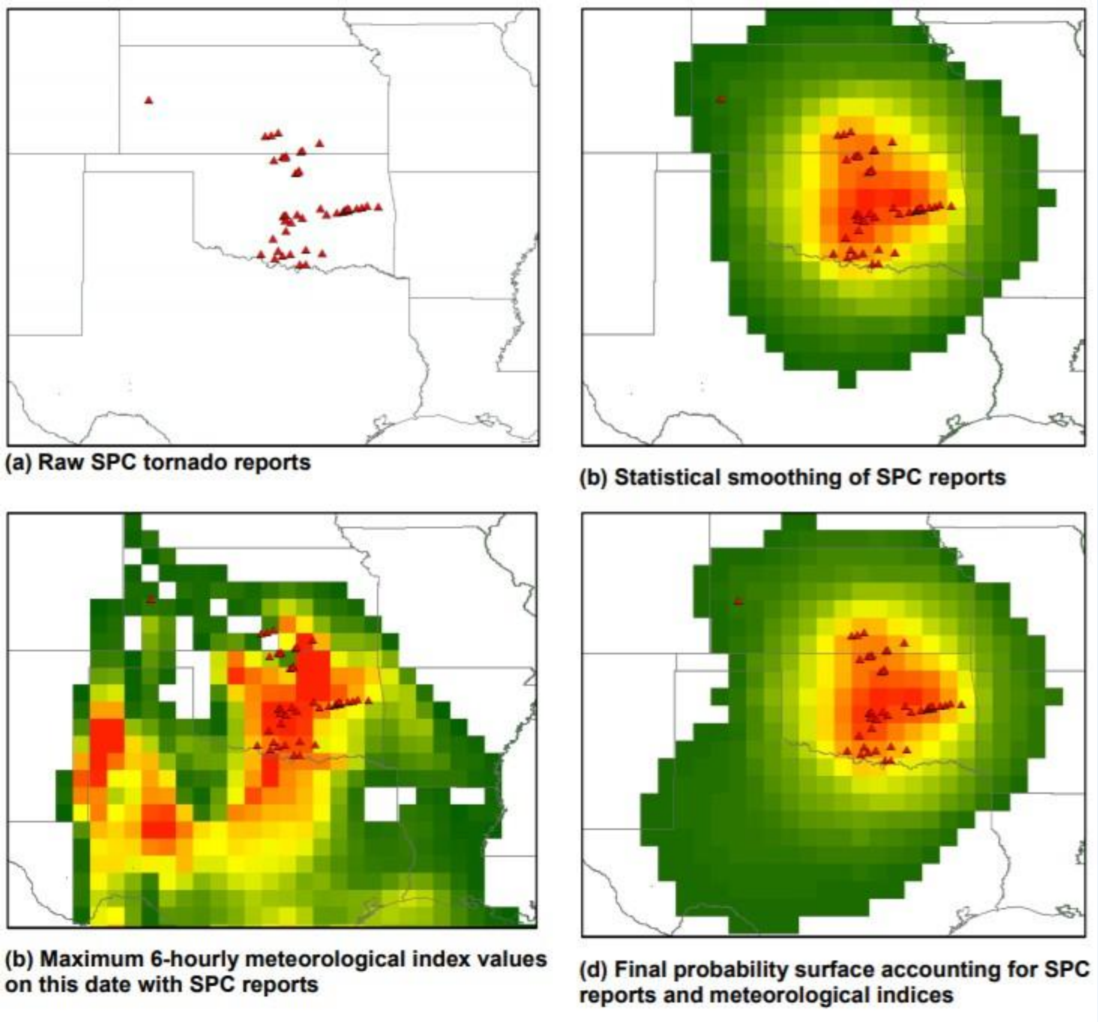
Step 1	Step 2	Step 3	Step 4
Simulate stochastic years of atmospheric conditions by re-sampling days from a historical set of numerical model output and preserving seasonality.	Given a CAPE and shear value for an analysis grid cell, get a probability distribution for each cell in an event that depends on the atmospheric state.	Place tornado, hail and straight-line winds in each cell using probability distributions and historical data.	Combine activity patterns over several days into events.

RMS: NARR (North America Regional Reanalysis Data)

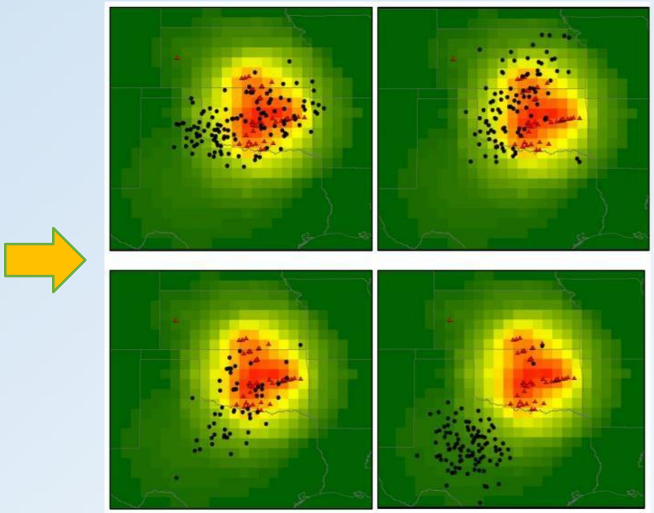
AIR: CFSR (Climate Forecast Systems Reanalysis)

Event Generation

HYBRID METHODOLOGY: METEOROLOGY AND STATISTICS



- Historical observational data is inherently biased and contains gaps (SPC reports)
- Research indicates that meteorological parameter values can indicate whether atmospheric conditions are favorable for severe weather (CAPE, shear)
- Combining these data sources and techniques can yield realistic outbreak patterns, such as the 4 simulated scenarios below, derived from the same risk surface

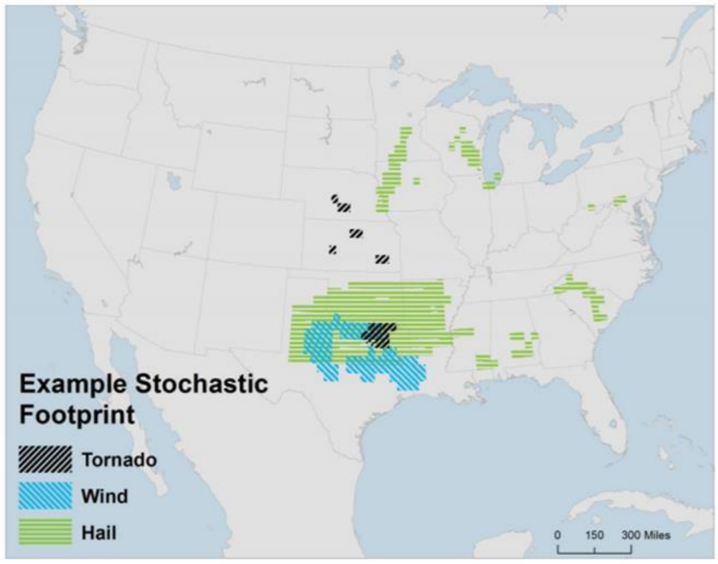


Event Footprints

DEFINING HAZARD FOR INDIVIDUAL EVENTS

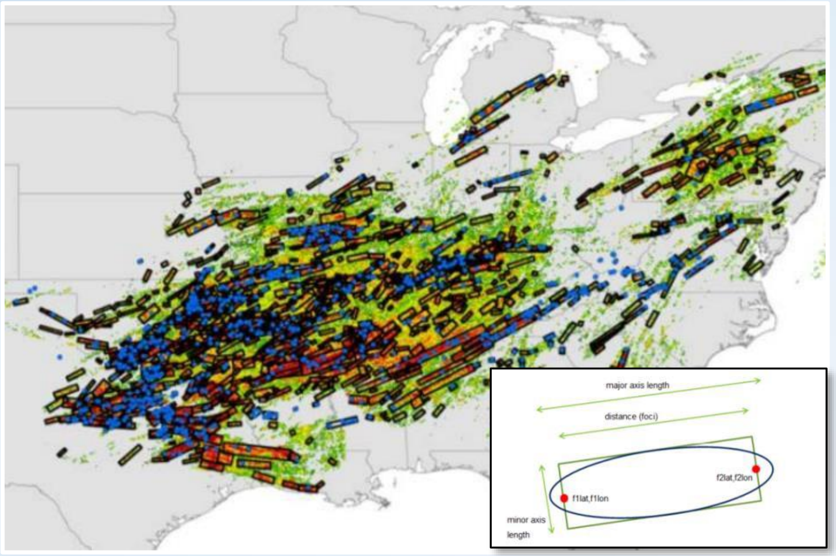
RMS: GRID METHODOLOGY

- The high-resolution model of all hail, SLW and tornado swaths in an event is overlaid onto the variable resolution grid (VRG) to create the stochastic footprint.
- *The hazard recorded at each location reflects the percentages of the VRG cell affected by each peril*
- Creates a fairly smooth hazard surface



AIR: FOOTPRINT METHODOLOGY

- SPC swath information was used to derive realistic length and width patterns, that were applied to the stochastic set
- *Rectangular grids were translated to ellipses to represent physical nature of peril swaths*
- Very distinct boundary between being in the event and being out of the event
- Creates significant variations in loss by location

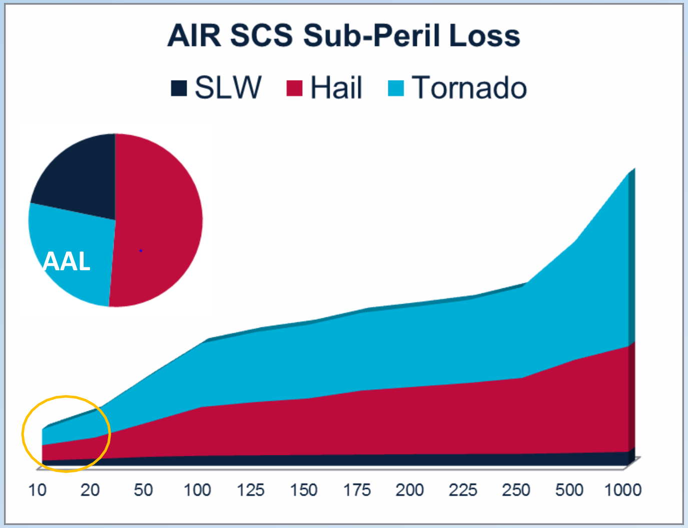


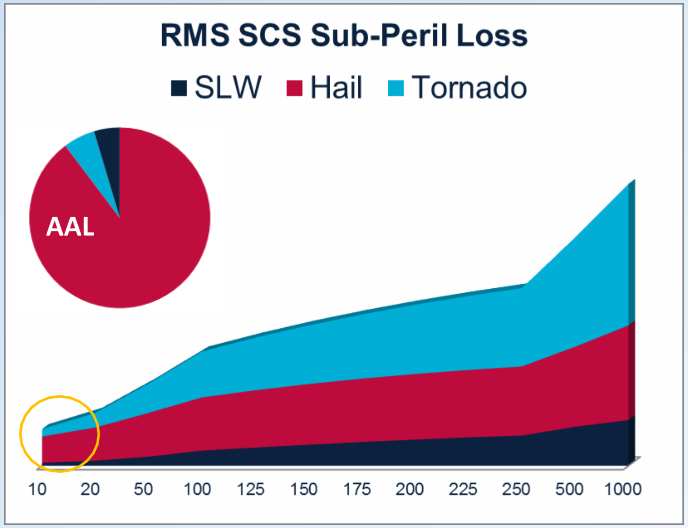
Multi-Peril Methodology

COMBINING HAIL, SLW, TORNADO PERILS

- AIR:
  - Calculate mean damage ratio (MDR) for each individual sub-peril
  - Take the ***maximum MDR*** of Wind and Tornado per event
  - After wind sub-perils are accounted for, hail damages what is left over
  - AIR views the tornado and hail perils to be relatively equal at all return periods, with SLW being a very minor component***

- RMS:
  - Goal is to avoid double or triple counting losses (ie counting hail damage to a roof that has been blown off by a tornado)
  - RMS views hail as being a more dominant peril at shorter return periods
  - At longer return periods, wind peril begins to dominate, including SLW



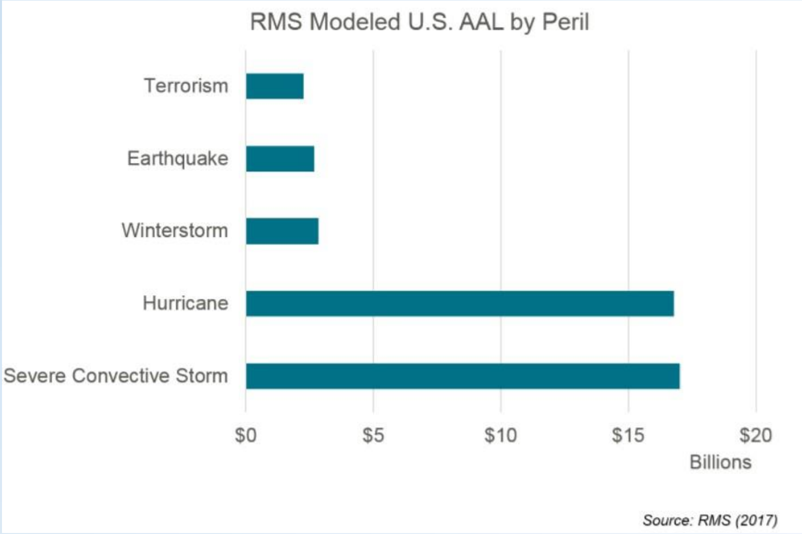


*** For a representative midwestern portfolio of risks

Why do we model scs?

INCREASINGLY IMPORTANT PERIL

- Severe Thunderstorm Models estimate the frequency, severity, and geographical distribution of potential losses from straight-line winds, hail, and tornadoes and lightning (RMS only)
- The United States has the most active severe convective storm climatology in the world. Canada ranks as the second most active
- Models have been developed using state of the art scientific methodologies/data and calibrated using a wealth of claims data from recent events
- Models not only capture the highly complex nature of individual event footprints (microevents), but also realistically group single events into multi-peril outbreaks (macroevent), and capture the seasonality of hazard
- While severe thunderstorm is a relatively high frequency peril, aggregate losses can result in extreme volatility in financial results, making it crucial for companies to have a robust and highly granular view of the risk
- With the introduction of lower medium term rates in the RMS Hurricane Model, in 2017 Severe Convective Storm AAL has now exceeded Hurricane AAL to become to costliest US peril

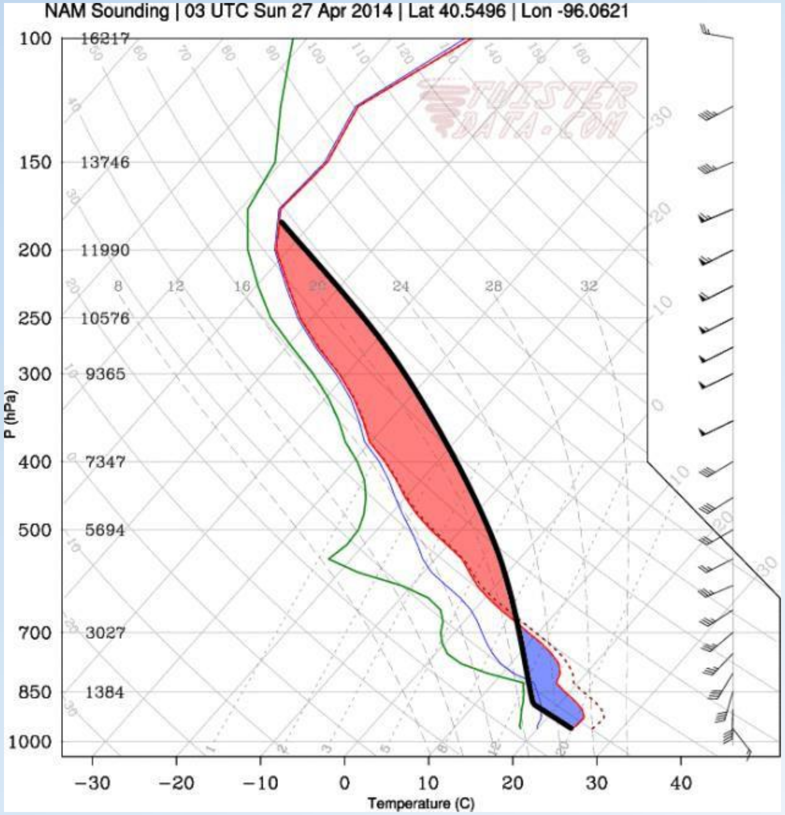


6 Appendix

Atmospheric Caps

WHO NEEDS A COLD FRONT?

- Loss of daytime heating overnight can cause the earth's surface to cool faster than the air above – builds warm air aloft most nights and mornings (an "inversion")
- Once the sun has a chance to heat the surface throughout the morning, warm air and humidity near the surface builds underneath the warmer air aloft
- Throughout the afternoon, the warm air aloft that's acting like a lid ("cap") will begin to erode as rising cooling parcel of moist air gradually penetrate and mix in
- Eventually the lid can no longer suppress the pent-up keg of heat and humidity beneath it and the hot, humid air can violent break through



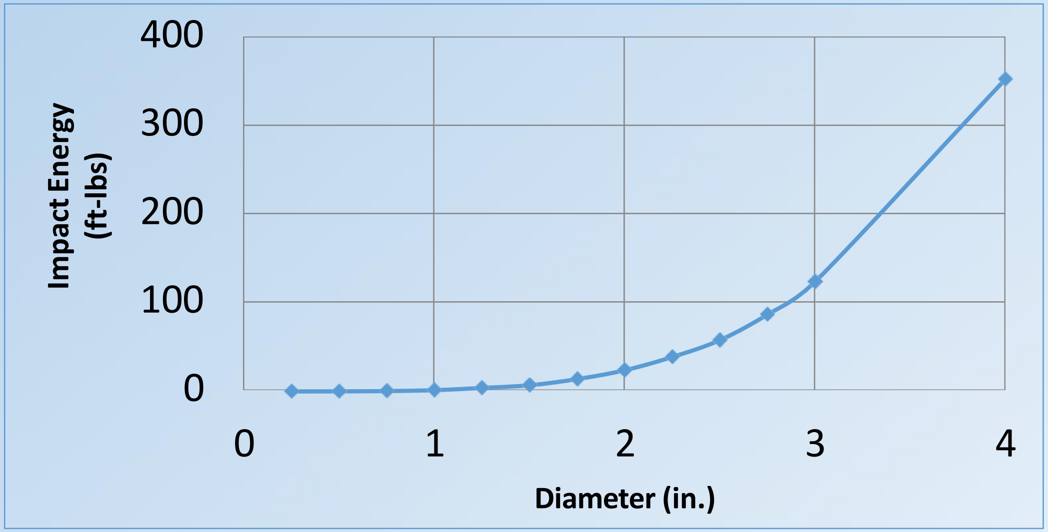
Hail Formation & Growth

- Growth depends on the complicated interaction between the airflow within a deep convective cloud and precipitation particles
- They primarily grow by the collection of supercooled cloud droplets and raindrops (with some ice particles present)
- After 5 – 10 minutes of ice crystal growth within the updraft of a thunderstorm via vapor deposition, the crystals acquire enough mass to descend relative to the supercooled cloud droplets, which freeze immediately upon contact with the ice particles.
- This collection of supercooled cloud droplets leads to the formation of nearly spherical graupel particles with diameters of a few millimeters
- The growing ice particles become larger, fall faster relative to the air, and consequently sweep out more supercooled droplets because of a larger cross-sectional area, leading to an even faster growth rate – this process continues as long as the fall speed of the hailstone is less than the updraft speed of the storm
- The ideal conditions for hail growth are when the hailstone fall speeds nearly match the updraft velocity when the ice particles enter the portion of the updraft where the supercooled liquid water concentration is large

Hail size vs. structural impact

THE SCIENCE

- Size Factors and Impact
- Hailstones can grow to diameters of 4 inches or larger if the updraft is intense and ultimately the hailstones descend when their fall speeds exceed the updraft speed
- The final size that the hailstone can achieve is a function of the liquid water concentration and the time that the hailstone can reside in the region of high supercooled liquid water content
- The greater the diameter, the greater the resulting mass, terminal velocity, and compressive force upon impact.
- Doubling the size of the hailstone increases its compressive force upon impact by roughly 16x



2.5” hail in Billings, MT
May 18, 2014

3.5-4” hail in Norfolk, NE
June 3, 2014

Producers of Straight-Line Winds

DOWNDRAFTS, SQUALL LINES & DERECHOS… OH MY!

- Damaging straight-line winds within convective storms are almost always associated with the precipitation-cooled outflow (with some exceptions)

- Outflow-related damaging winds are usually produced by either “downbursts” or mesoscale cold pools associated with horizontal gradients in pressure large enough to produce damaging winds

- These winds usually occur from either:

  1. Intense downdrafts from an isolated supercell thunderstorm
  2. Long-lived mesoscale convective system’s (MCS) rear-inflow jet or deep cold pool outflow
  3. Low-topped squall lines or rain bands with strong gradient winds
  4. Derechos; widespread damaging wind event associated with long-lived deep, moist convection

Interpreting output

WHAT DOES THE EP CURVE TELL US?

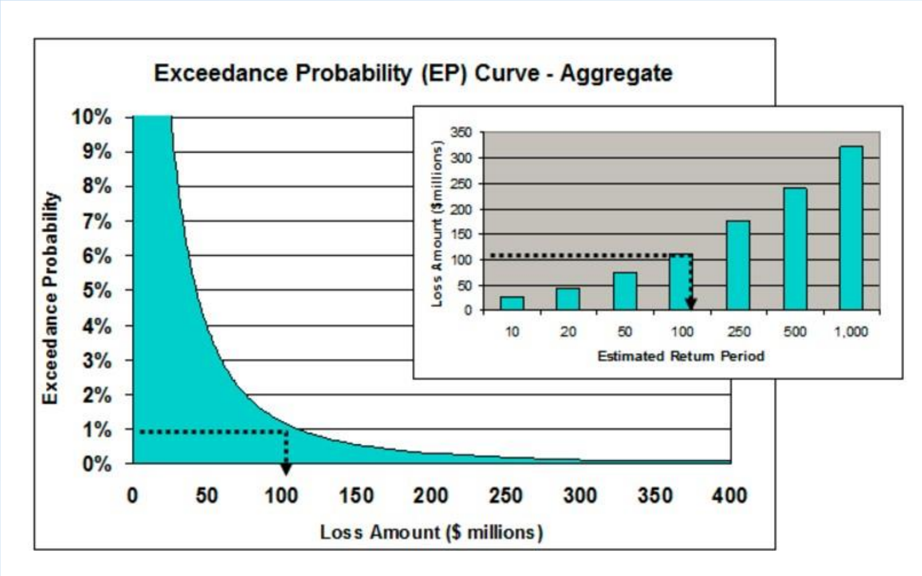
Average Annual Loss (AAL): the amount of modeled premium an insurer needs to collect in order to cover average peril loss over time

- Combination of event frequency and mean event loss

Exceedance Probability (EP) curve: the probability of exceeding a loss level in a given year; most often referred to as ‘return period’

Two types of EP curve:

- Occurrence Exceedance Probability (**OEP**): gives the probability of a *single loss* of a given size or larger in a year
- Aggregate Exceedance Probability (**AEP**): gives the probability of *total losses* in the year of a given size or larger



EXAMPLE:

AEP curve shows that your 1% EP is USD 100 million.

- ✓ You have a 1% probability of having losses of USD 100 million or greater each year.
- ✓ As a long-term average, a loss of USD 100 million or greater in a year will occur once every hundred years (the key term here being “long-term average”).
- ✓ A loss of USD 100 million has a return period of 100 years (since 1/.01 = 100)

Advanced Topics in Vulnerability

September 13, 2018

Anna Milliken

Senior Risk Analyst, RLI

Vulnerability

- Describes the relationship between particular characteristics of a hazard and the effect it will have on damage incurred to a particular risk
- How extensive will the damage be?

Hazard is the danger or risk

Vulnerability is being exposed to possibility of harm.

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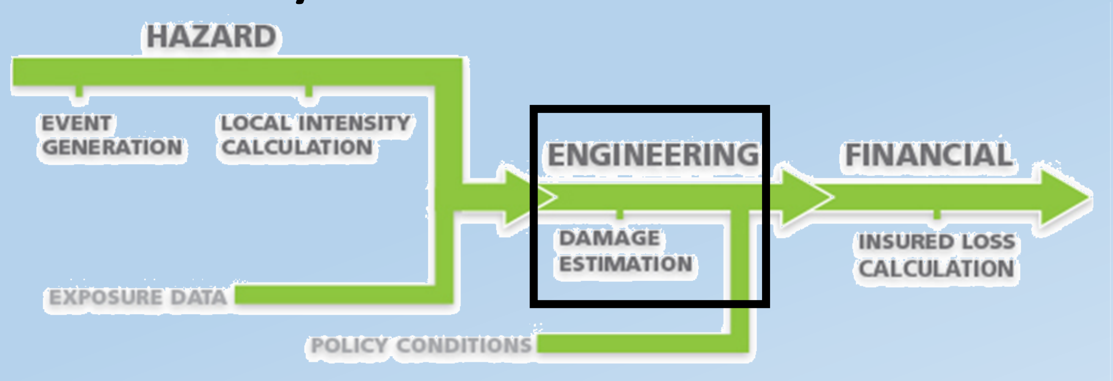
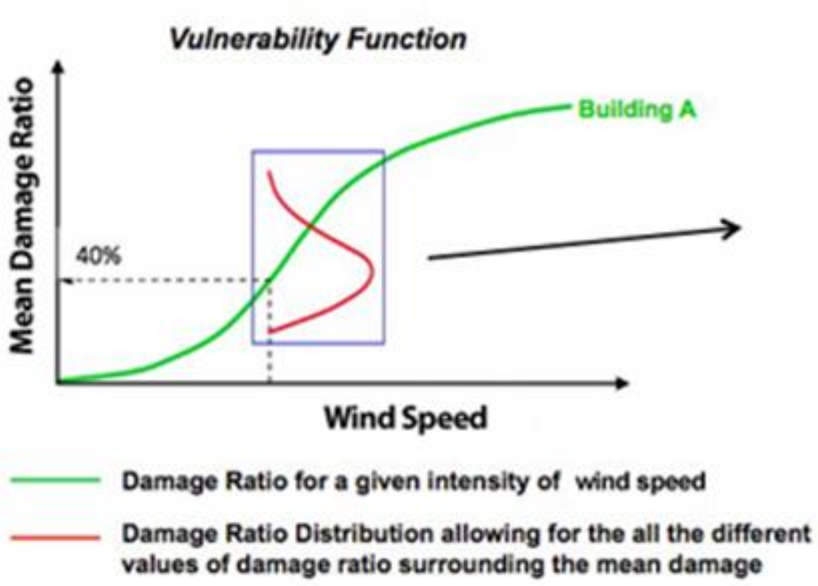
Vulnerability in the Model



- Calculates the amount of expected damage to the properties at risk
- Critical estimates of uncertainty around expected damage
- Derived from experience and engineering

Vulnerability Curve

- To capture variability in damage, look at a whole distribution of possible values
- The mean of this distribution is known as the mean damage ratio
  - MDR = average loss/replacement value
- Mean damage ratio as function of intensity is called a vulnerability function



Functions of Vulnerability Curve

- Vary by:
  - Building Characteristics – construction type, occupancy, building height, year built
  - Coverage – building, contents, time element coverages
  - Region
- Each feature reduces the vulnerability of a property, but can increase or decrease the average loss
- Generally ‘unknown’ data is treated more conservatively

Sources of Vulnerability

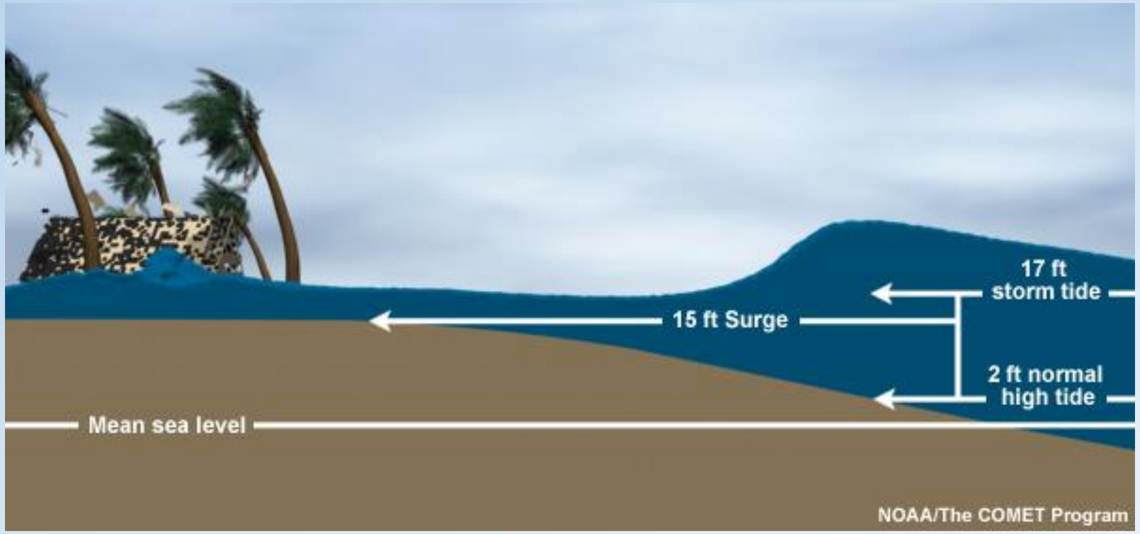
- Actual damage data historically is scarce, especially for severe events
- Inability to separate out the damage caused by different elements of a hazard (wind vs flood?)
- Need for smooth damage distribution to quantify a loss that may occur in a more complex manner

Model Uncertainty

- How can modelers be certain?
- Primary uncertainty
  - Data quality and completeness
  - Incomplete scientific understanding
- Secondary uncertainty
  - Uncertainty of damage & loss estimation should a given event occur
  - Standard deviation around the vulnerability curve
- Vulnerability module may be the most uncertain, most complicated, and most influential

Effects of Vulnerability

- Model misuse
- Garbage in, garbage out
- Model bias
- Managing to single loss output
- Lack of consideration for non modeled risk



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Managing Vulnerability

- Generalization to a base vulnerability curve works when set of risks is large
- Greater care required during a post-event assessment
- Understand model vender's generalizing assumptions and identify any biases in portfolio
- Test portfolio's sensitivity
- Data: consistency, completeness, accuracy

Trusting the Model

- Models are calibrated
- Models are 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

Trusting the Model

- Utilize the models but don’t rely solely on them
  - Provide a range of possibilities
  - Balance the model view
  - Maintain healthy skepticism

Vulnerability

- Uncertainty is inherent in loss estimation
- Vulnerability module may be the most uncertain
- Understand assumptions to trust the model

Advanced Topics in Financial Module

September 13, 2018

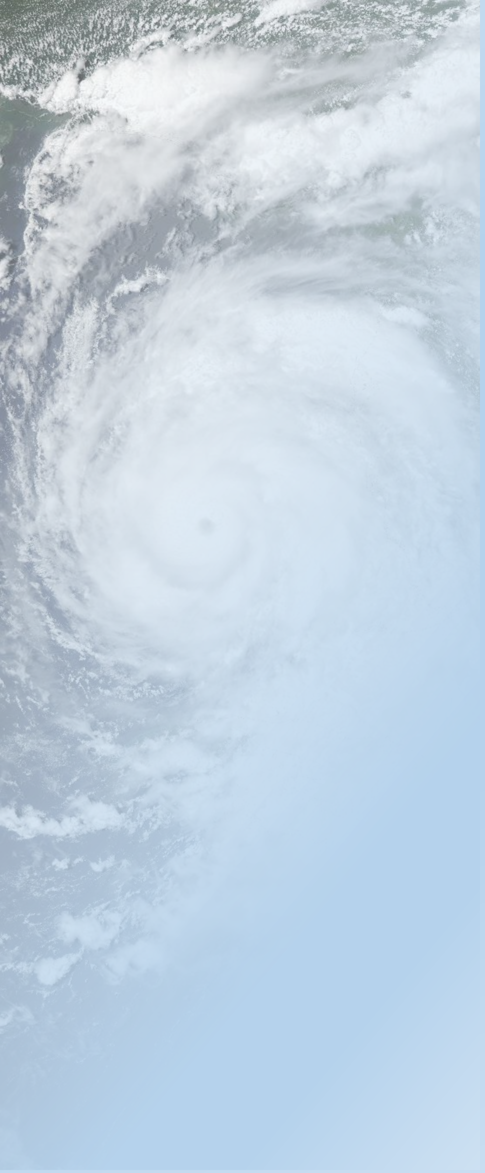
Susan Denike

Guy Carpenter

TABLE OF CONTENTS

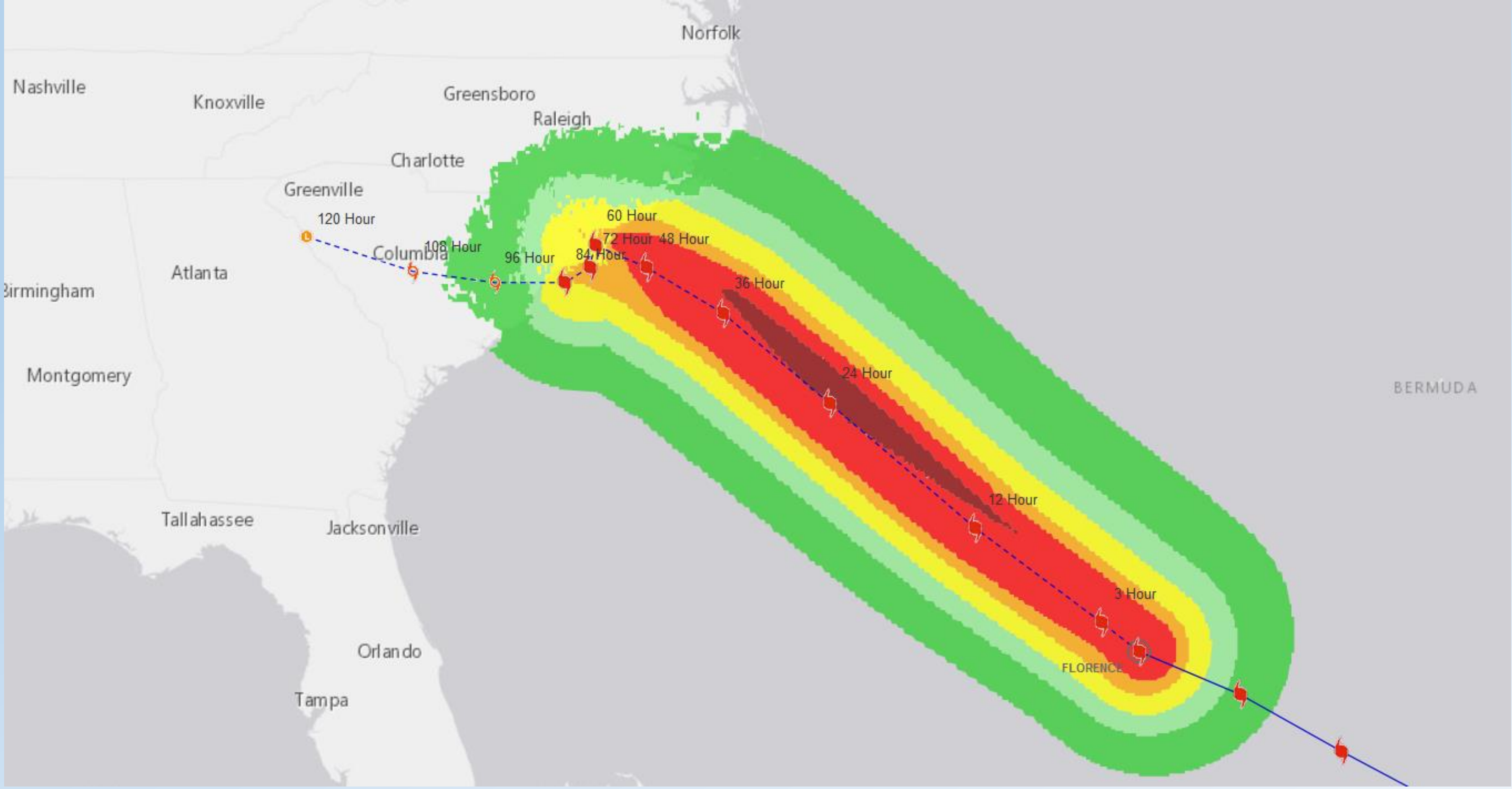
Section 1

Model Components



Model Components

Hazard Module – Hurricane



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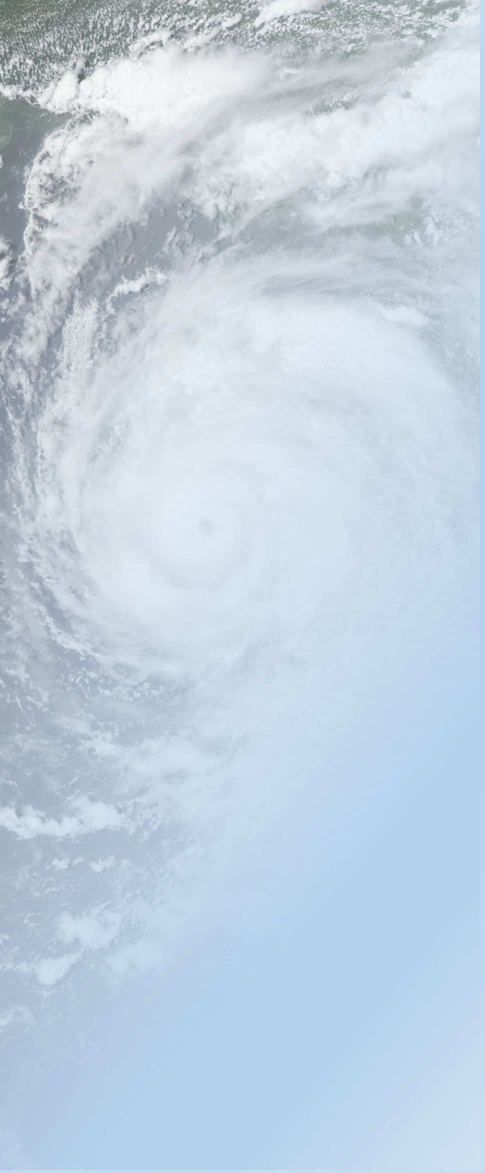
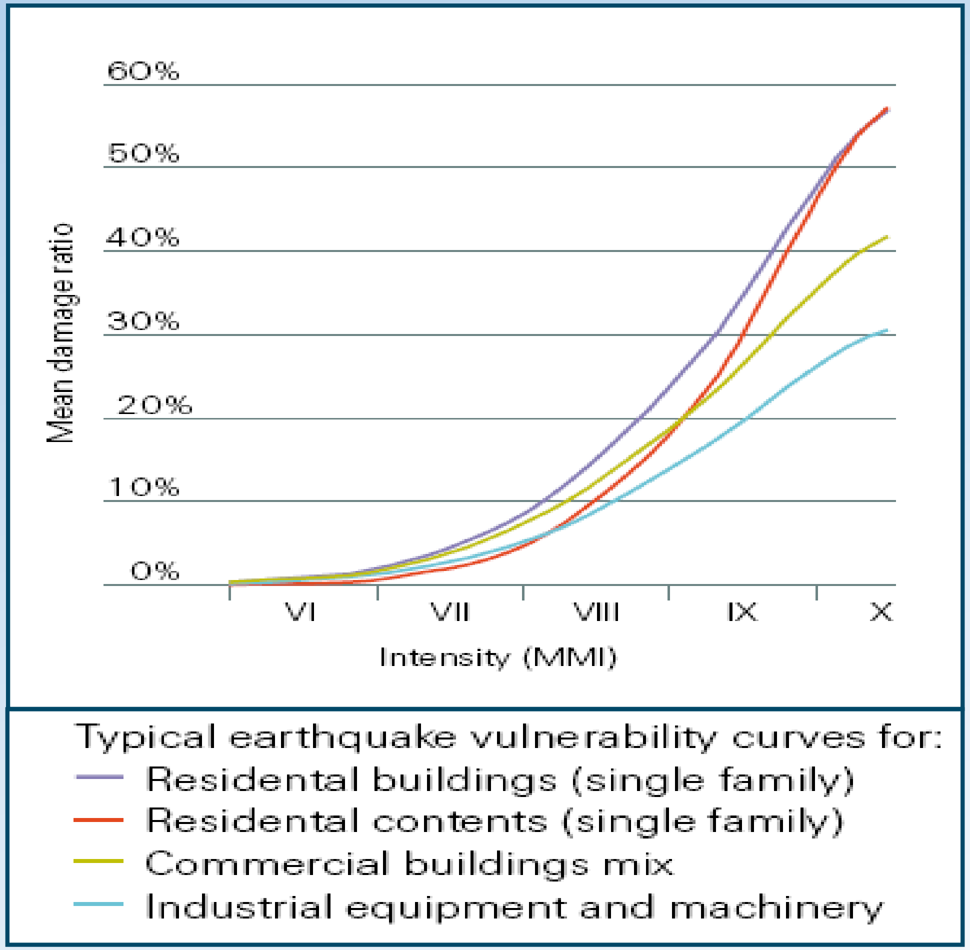


Model Components
Vulnerability Module

- Calculates the expected amount of physical damage
- Expressed as mean damage ratio (MDR): damage cost/sums insured
- Derived using claims data and engineering analysis
- Dependent on building attributes:
  - Occupancy type
  - Construction materials
  - Height
  - Year Built
  - Secondary Risk Characteristics



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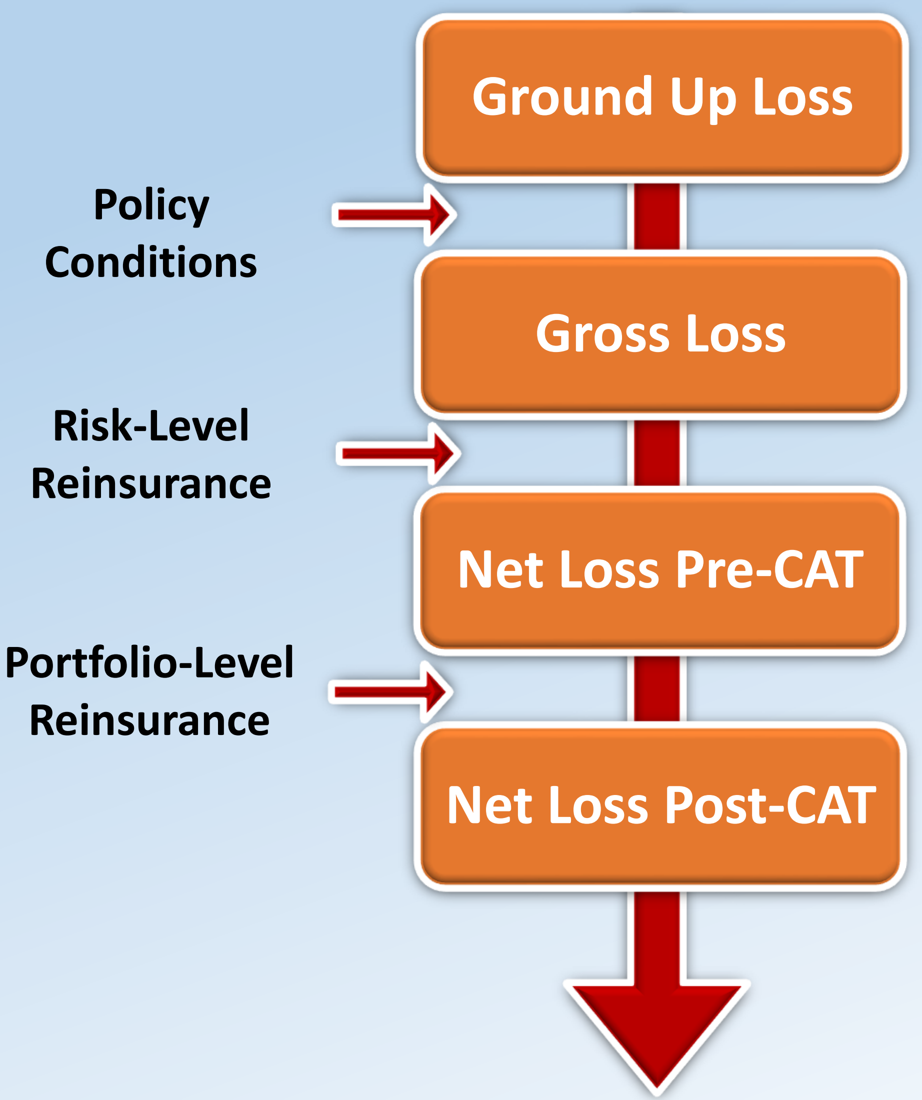
Model Components
Financial Module

Financial terms are applied:

- To Ground-Up loss to get Gross Loss
    - Limits on coverage, site or policy level
    - Deductibles on coverage, site or policy level, attachment points
    - Co-insurance / Pro Rata Shares
- To Gross Loss to get Net Loss pre-CAT
    - Facultative Reinsurance
    - Semi-Automatic / Surplus Share s
    - Quota Share
    - Non-proportional
- To Net Loss pre-Cat to get Net Loss Post-Cat
    - Catastrophe Treaty
    - Aggregate Treaty



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Model Components
Rebuild Value

Two models with similar industry loss curves, but persistently show large differences for insurer losses. For example,

Return Period	Model A	Model B
10	a10	4.0 x a10
25	a25	2.9 x a25
50	a50	2.0 x a50
100	a100	1.7 x a100
200	a200	1.9 x a200
250	a250	2.1 x a250
300	a300	2.3 x a300
400	a400	2.4 x a400
500	a500	2.3 x a500
1000	a1000	2.5 x a1000
Mean Loss	Avg	5.5 x Avg
Std Dev	Stdev	2.5 x Stdev

In this particular example, Model B value/per risk is half of insurer data. Model A valuation is closer to insurer data. Hence, to use the models properly, users should consider adjusting exposures to the level intended by the model builders.

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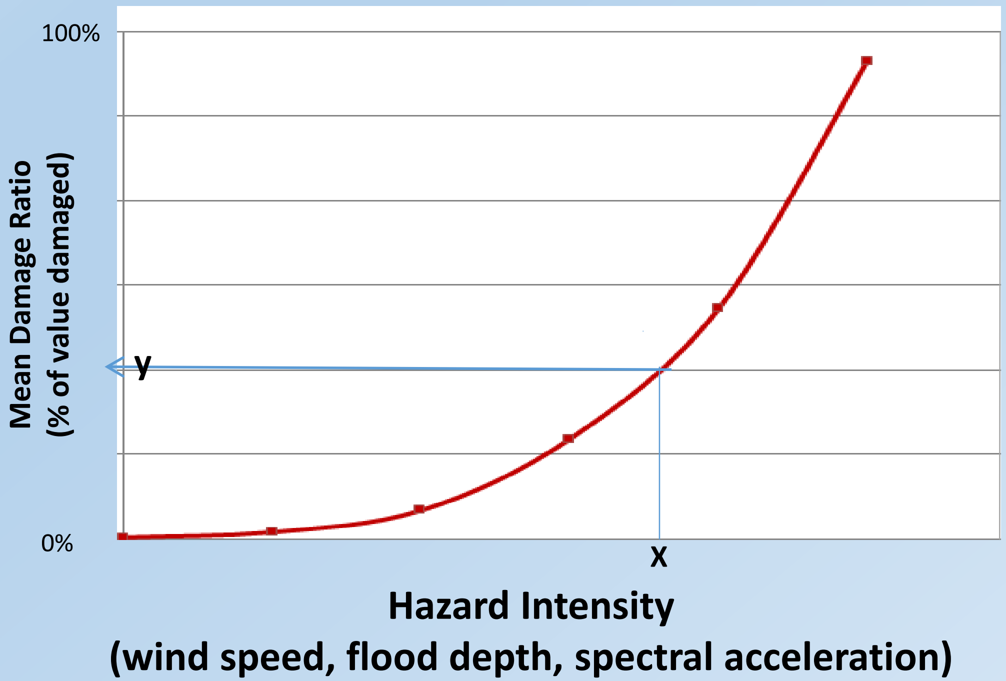
Section 2

Understanding Secondary Uncertainty

Secondary Uncertainty
Uncertainty of damage around the mean value

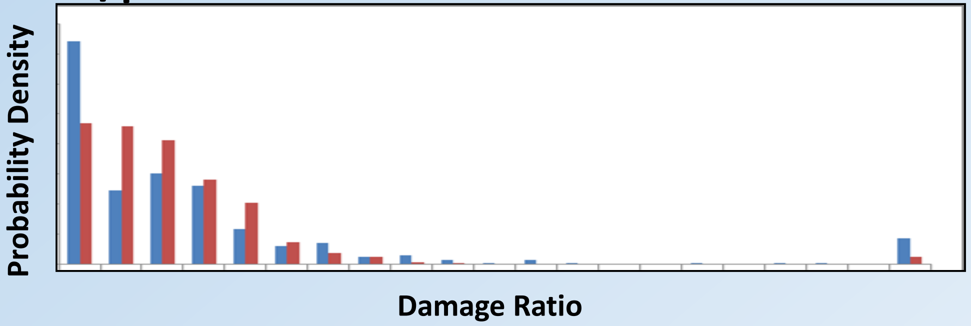
Mean Damage Ratio by Hazard Intensity



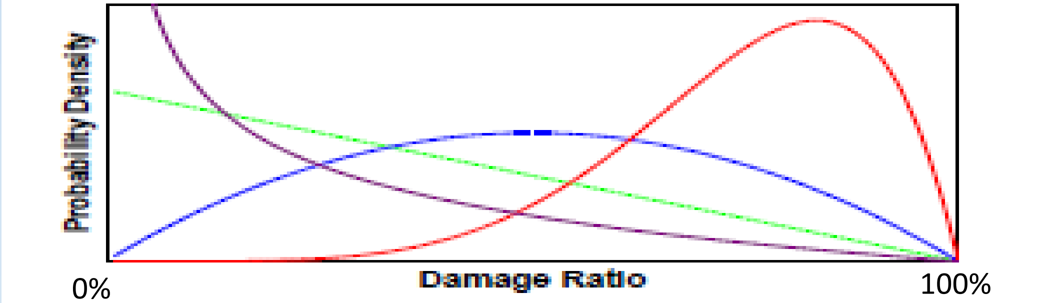
For every intensity, x, there is a mean damage ratio, y, which has a distribution around it,

Damage distribution around a mean

A. Empirical distribution w/positive mass at zero and total loss



B. Continuous distribution



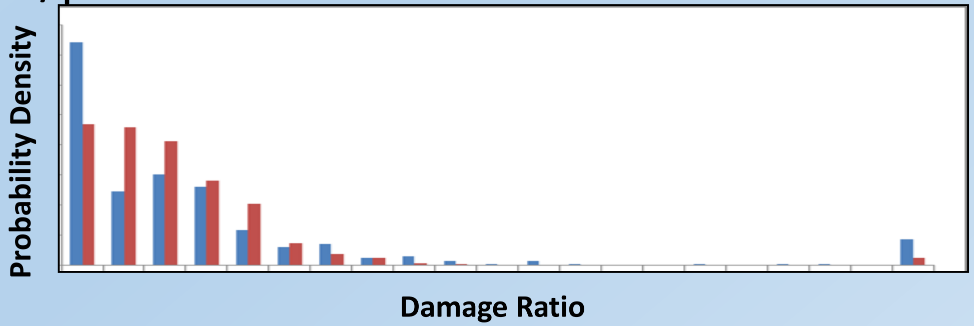
Mixed Distribution: continuous distribution with positive mass at end points are possible. Our illustrations use only the two simpler cases.

Implications

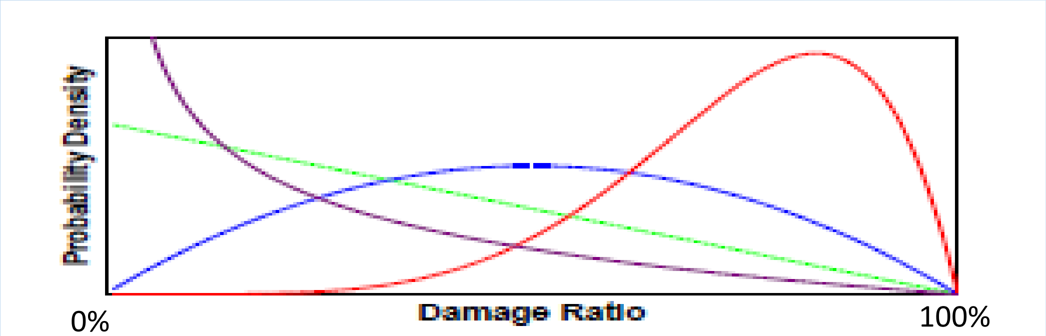
Impact of Empirical vs Continuous Damage Distribution

Damage distribution around a mean

Empirical distribution
w/positive mass at zero and total loss



Continuous distribution



Empirical vs Continuous Damage Distributions around the Mean

If the weights in Model A are concentrated in a narrow range of damage ratios for a particular country/peril, and the events get more severe by hitting more risks, the deductible effect does not vary very much, and the GR/GU ratio are similar across return periods.

With Model B, the damage function stretches continuously from 0% to 100% loss. When the events get more severe, the losses increase, and deductibles have smaller impact. So, the GR/GU ratio increases as return period goes up.

Implications

Portfolio OEP by Deductible Options

Return Period	No Ded	5% Loss	10% Loss	5% TSI	10% TSI
1000	120.2m	114.2m (95%)	108.2m (90%)	67.7m (56%)	60.8m (51%)
500	97.7m	92.8m (95%)	88.0m (90%)	60.6m (62%)	53.3m (54%)
250	79.3m	75.3m (95%)	71.4m (90%)	50.1m (63%)	44.5m (56%)
200	72.5m	68.9m (95%)	65.3m (90%)	46.7m (64%)	40.7m (56%)
100	53.3m	50.6m (95%)	48.0m (90%)	34.7m (65%)	31.1m (58%)
50	40.8m	38.7m (95%)	36.7m (90%)	28.4m (70%)	25.4m (62%)
25	30.7m	29.2m (95%)	27.7m (90%)	21.3m (69%)	19.0m (62%)
20	28.4m	27.0m (95%)	25.6m (90%)	19.5m (69%)	17.4m (61%)
10	20.9m	19.9m (95%)	18.8m (90%)	14.1m (67%)	12.6m (60%)
5	14.0m	13.3m (95%)	12.6m (90%)	9.1m (65%)	8.1m (58%)
AAL	15.6m	14.8m (95%)	14.0m (90%)	8.9m (57%)	7.9m (51%)
Stdev	17.2m	17.2m (100%)	15.5m (90%)	10.7m (62%)	9.4m (54%)

Empirical Distribution w/ Narrow Damage Ratios

Return Period	No Ded	5% Loss	10% Loss	5% TSI	10% TSI
1000	193.0m	183.4m (95%)	173.7m (90%)	92.1m (48%)	60.5m (31%)
500	156.8m	148.9m (95%)	141.1m (90%)	66.4m (42%)	40.2m (26%)
250	125.6m	119.3m (95%)	113.0m (90%)	46.1m (37%)	25.1m (20%)
200	116.2m	110.4m (95%)	104.6m (90%)	40.5m (35%)	21.2m (18%)
100	88.2m	83.8m (95%)	79.4m (90%)	25.8m (29%)	11.6m (13%)
50	62.0m	58.9m (95%)	55.8m (90%)	14.7m (24%)	5.3m (9%)
25	40.0m	38.0m (95%)	36.0m (90%)	7.0m (17%)	1.7m (4%)
20	34.2m	32.5m (95%)	30.8m (90%)	5.2m (15%)	1.1m (3%)
10	19.4m	18.4m (95%)	17.4m (90%)	1.5m (8%)	0.1m (1%)
5	8.9m	8.5m (95%)	8.0m (90%)	0.2m (2%)	0.0m (%)
AAL	9.6m	9.1m (95%)	8.6m (90%)	1.3m (13%)	0.5m (5%)
Stdev	20.1m	19.1m (95%)	18.1m (90%)	7.6m (38%)	5.1m (25%)

Continuous Distribution

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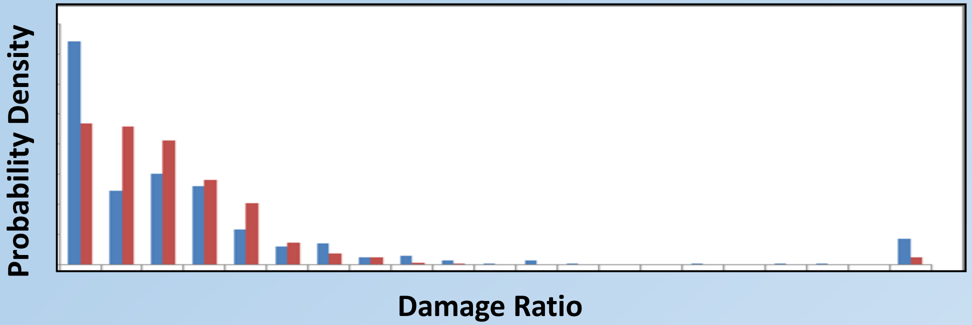
Implications

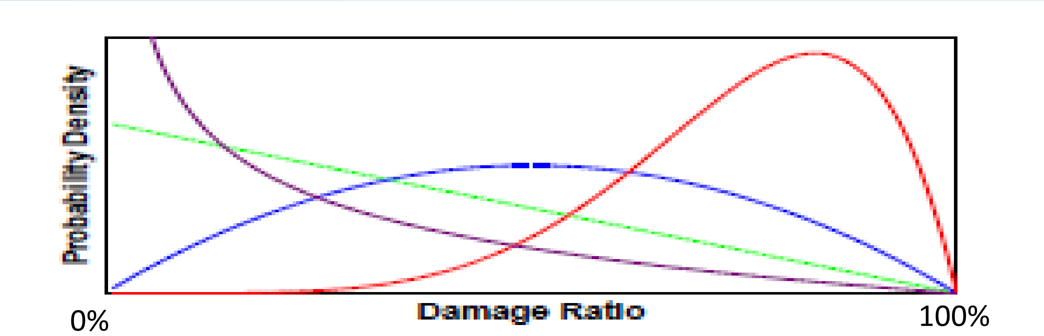
Impact of Limit on Results with Demand Surge

Damage distribution around a mean

Empirical distribution
w/positive mass at zero and total loss



Continuous distribution



When we run the model with demand surge and we have limit = exposure.

With Model A, sometimes a total loss can exceed the exposure. If there is a limit = exposure, then the loss will be capped by the limit. So, gross loss will be noticeably smaller than ground-up loss in events where there are large probabilities for a total loss.

With Model B, there is only a small probability of losses exceeding the exposure. Hence, the gross loss is not as different from the ground-up loss.

Therefore, we are more likely to see a smaller GR/GU ratio in A than B.

Modeling With/Without Secondary Uncertainty

Option to run the model with no secondary uncertainty on the damage curves

Value: Examine mean damage value and check correct application of policy terms

Option to run the model with no secondary uncertainty at the event level

Value: An implementation decision to make computations more efficient. However, results may be very different for small portfolios, for example for a portfolio with high attachment point and low limits (E&S portfolio), and for hazards that are rare, In these cases, better to use results with secondary uncertainty.

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Section 3

Understanding Correlation

Portfolio Results w/Correlation

Correlation

Full Correlation

Result: If an insurer acquires a book, simply “add” by-year-by-event loss to obtain the combined portfolio return period results. If an insurer writes one risk in a condo complex, and then writes another risk there, then the results will simply double across all return periods. No diversification effect.

Partial Correlation

Result: If an insurer acquires a book, take correlation of the risks into account in computing the new combined portfolio return period results.

If an insurer writes one risk in a condo complex, and then writes another risk there, the results for the lower return periods will likely be more than 2x the original, and the results for the larger return periods will likely be lower than 2x the original.

The principle is: when the event is mild, there is some chance that not both risks get the mild treatment. Similarly, when the event is extreme, there is some chance that not both risks suffer the large damage. This is also known as diversification effect.

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Test 1: Checking Correlation for a Portfolio of 2 Identical Risks

Number of risks=1 in each location, multiple records

- Building value: 10 Million
- Number of risks: 2 separate records

Return Period (Years)	Doubling Benchmark Losses	A portfolio of Two Benchmark Risks	% Change
1,000	2,341,920	2,341,920	0%
500	1,547,144	1,547,144	0%
250	766,048	768,261	0%
200	637,907	637,908	0%
100	382,482	382,482	0%
50	217,645	217,645	0%
25	129,200	129,200	0%
20	110,020	110,020	0%
10	67,180	67,180	0%
5	36,520	36,520	0%
AAL	38,653	38,653	0%
STDEV	206,342	206,342	0%

No Diversification Effect

Return Period (Years)	Doubling Benchmark Losses	A portfolio of Two Benchmark Risks	% Change
1,000	1,289,701	1,007,296	-22%
500	898,232	734,885	-18%
250	590,535	510,024	-14%
200	508,524	447,450	-12%
100	303,398	284,053	-6%
50	162,914	165,599	2%
25	70,997	83,798	18%
20	50,008	63,560	27%
10	10,683	18,112	70%
5	502	1,596	218%
AAL	14,103	14,103	0%
STDEV	104,994	82,639	-21%

Diversification Effect

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Test 2: Checking Correlation for 2 Portfolios
Splitting Coverages

- Coverage value:
  - Portfolio A: 1 policy with Building=10M and Content = 5M
  - Portfolio B: 2 policies, one with Building=10M, one with Content = 5 M, separately
- Number of risks: 1

Return Period (Years)	Portfolio A	Portfolio B	% Change
1,000	1,331,404	1,331,404	0%
500	877,645	877,645	0%
250	423,596	423,596	0%
200	370,241	370,241	0%
100	221,042	221,042	0%
50	135,287	135,287	0%
25	86,057	86,057	0%
20	76,905	76,905	0%
10	49,486	49,486	0%
5	27,766	27,766	0%
AAL	26,081	26,081	0%
STDEV	135,650	135,650	0%

No Diversification Effect

Return Period (Years)	Portfolio A	Portfolio B	% Change
1,000	1,781,795	1,544,888	-13%
500	1,285,944	1,145,069	-11%
250	862,764	789,865	-8%
200	744,954	688,576	-8%
100	439,894	421,796	-4%
50	224,353	228,418	2%
25	88,172	100,860	14%
20	59,436	71,928	21%
10	11,215	16,340	46%
5	432	1,010	134%
AAL	18,647	18,647	0%
STDEV	125,961	111,662	-11%

Diversification Effect

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Test 3: Comparing Gross Loss for 2 Policies

Site and Policy Ded for Numbldgs > 1

- **Building value:** 1 Billion
- **Number of risks:** 100

- **Deductibles:**
  - Policy A with Total Site Deductibles 5 Million
  - Policy B with Policy Deductible 5 Million

Return Period (Years)	Policy A	Policy B	% Change
1,000	112,097,359	112,097,359	0%
500	72,408,781	72,408,781	0%
250	34,030,767	34,030,767	0%
200	27,918,879	27,918,879	0%
100	16,054,010	16,054,010	0%
50	8,993,942	8,993,942	0%
25	5,447,447	5,447,447	0%
20	4,715,125	4,715,125	0%
10	2,942,942	2,942,942	0%
5	1,601,594	1,601,594	0%
AAL	1,679,241	1,679,241	0%
STDEV	9,980,100	9,980,100	0%

No Diversification Effect

Return Period (Years)	Policy A	Policy B	% Change
1,000	19,262,311	16,998,030	-12%
500	15,960,702	13,674,179	-14%
250	12,622,875	10,202,234	-19%
200	11,508,323	9,001,134	-22%
100	7,943,808	4,856,545	-39%
50	4,806,491	1,409,862	-71%
25	2,611,788	124,366	-95%
20	2,062,201	25,702	-99%
10	737,941	0	-100%
5	59,928	0	-100%
AAL	395,423	145,777	-63%
STDEV	1,702,128	1,256,865	-26%

Different Diversification Effect.
5 million in Policy Ded is guaranteed to apply in B. Thus, losses are lower.

Correlation
Impact on Portfolio Aggregation

1. If two entities, A and B, share a portfolio 50/50
2. If each entity models with 50% of the sums insured
3. If you combine the results of A and B

THEN,
In a model with full correlation, the higher (lower) return period results may be over (under)-estimated.

In a model with partial correlation, you need to decide if the diversification effect is appropriate.

Section 4

Financial Term Interpretations Impact on Model Conversion

Test 4: Comparing Treatment of Deductibles
Co-existence of site and policy deductible

- Building value: 10 Million
- Number of risks: 1
- Site Deductible: $50,000
- Policy Deductible: $50,000

Return Period (Years)	A Single Risk w/ Site Ded	A Single Risk w/ Site&Pol Ded	% Change
1,000	1,120,974	1,070,987	-4%
500	724,088	674,604	-7%
250	341,372	299,651	-12%
200	279,189	242,007	-13%
100	160,540	134,853	-16%
50	89,939	78,668	-13%
25	54,474	53,216	-2%
20	47,151	46,681	-1%
10	29,420	29,273	-1%
5	16,016	15,935	-1%
AAL	16,792	16,028	-5%
STDEV	99,801	97,132	-3%

If both site and policy deds are entered, both will be applied, one on top of the other.

Return Period (Years)	A Single Risk w/ Site Ded	A Single Risk w/ Site&Pol Ded	% Change
1,000	592,440	592,440	0%
500	388,983	388,983	0%
250	232,598	232,598	0%
200	191,800	191,800	0%
100	92,886	92,886	0%
50	32,281	32,281	0%
25	4,882	4,882	0%
20	1,772	1,772	0%
10	1	1	0%
5	0	0	0%
AAL	3,954	3,954	0%
STDEV	47,575	47,575	0%

If both site and policy deds are entered, the larger of the two will be applied

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Test 5: Comparing % Ded
Applied to exposure or limit?

- Building value: 10 Million
- Number of risks: 1
- Site Deductible: 5%
- Site Limit: 1 Million

Return Period (Years)	A Single Risk w/ Site Ded 5%*1 M	A Single Risk w/ Site Ded 5%	% Change
1,000	705,842	705,842	0%
500	538,516	538,516	0%
250	242,466	242,466	0%
200	185,468	185,468	0%
100	78,004	78,004	0%
50	22,238	22,238	0%
25	6,116	6,116	0%
20	4,715	4,715	0%
10	2,809	2,809	0%
5	1,529	1,529	0%
AAL	4,557	4,557	0%
STDEV	38,280	38,280	0%

Model A applies % ded to limit, if available.

Return Period (Years)	A Single Risk w/ Site Ded 5%*10 M	A Single Risk w/ Site Ded 5%	% Change
1,000	126,869	126,869	0%
500	12,523	12,523	0%
250	112	112	0%
200	10	10	0%
100	0	0	0%
50	0	0	0%
25	0	0	0%
20	0	0	0%
10	0	0	0%
5	0	0	0%
AAL	540	540	0%
STDEV	17,893	17,893	0%

Model B applies % ded to exposures

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Financial Structures
Special Conditions

- Special Conditions allow users to reflect peril- or geography-specific policy terms
- Can get very complicated particularly when a company is coding policies on a multi-peril basis
- Not well understood and frequently coded incorrectly
- Need to understand nuances between how special conditions are coded vs over-riding policy terms
- Model-specific differences:
  - Policy Restrictions
  - Multiple sub-limits per location

Financial Structures
Dependent Sub-Limits

- i.e Earthquake + Fire Following + Sprinkler Leakage or Wind + Storm Surge
- Can the model handle the dependency?
- Does your coding (and subsequent results) reflect the intent of the policy?
- Case – Multi-location, nationwide schedule:
  - Fire Limit: $50million part of $100million
  - Earthquake sublimit: $25million except $5million in California – both per occurrence and in the aggregate (IRO company's 50% share)
  - Sprinkler leakage contained in the Earthquake sublimit
  - Fire Deductible $250,000; Earthquake deductible 5% with max $500,000

Financial Structures
Is this Real Life?

There are a million ways to get tripped up in Financial Modeling:

- Proper coding of primary/secondary risk characteristics is important but do not lose sight of how significant the impact of the financial structures can be
- Coding of financial structures requires a thoughtful approach and knowledge of model quirks
- Think about how the policy or reinsurance should respond "in real life" and try to get the model to mimic that as closely as possible
- Available tools to ensure positive outcomes:
  - Accumulation Analyses
  - Expected Mode Analyses
  - Diagramming risks
  - Test Runs

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Section 5

Improvement: More Sampling

Simulation Approach
Greater Computing Power

Increased sampling of events and severities can improve the span of loss estimation:

1. Increased number of events in model catalogue or greater number of years of simulated events.

    Events can reach locations where they are rarely impacted.

2. Increased number of simulated severities for the same events.

    Damage can be realized in risks that are usually unaffected due to its building characteristics' resistance to the peril.

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