That Cost Me What!?

Demonstrating the Need and Utility of Catastrophe Models in Quantifying Severe Thunderstorm Risk

Eric Robinson

Principal Scientist, AIR Worldwide

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What is a Severe Thunderstorm?

AMS Glossary:

> **In general, any destructive storm, but usually applied to severe local storms in particular, that is, intense thunderstorms, hailstorms, and tornadoes.**

Primary Sub-perils

Straight-line Wind (> 50 knots)

Hail (>=1” in diameter)

Tornado (EF0-EF5)

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What is a Severe Thunderstorm?

Supercells

- Rotating, isolated
- Typical sub-perils
  - Tornado
  - Hail
  - Wind/downbursts
- Typical dimensions
  - Duration: hours
  - Spatial: ~100-1,000s of km^2

Multicells (Squall Lines, Derechos)

- Long-lasting
- Typical sub-perils
  - Wind/downbursts
  - Hail
  - Tornado
- Typical dimensions
  - Duration: days
  - Spatial: ~10,000-100,000s of km^2

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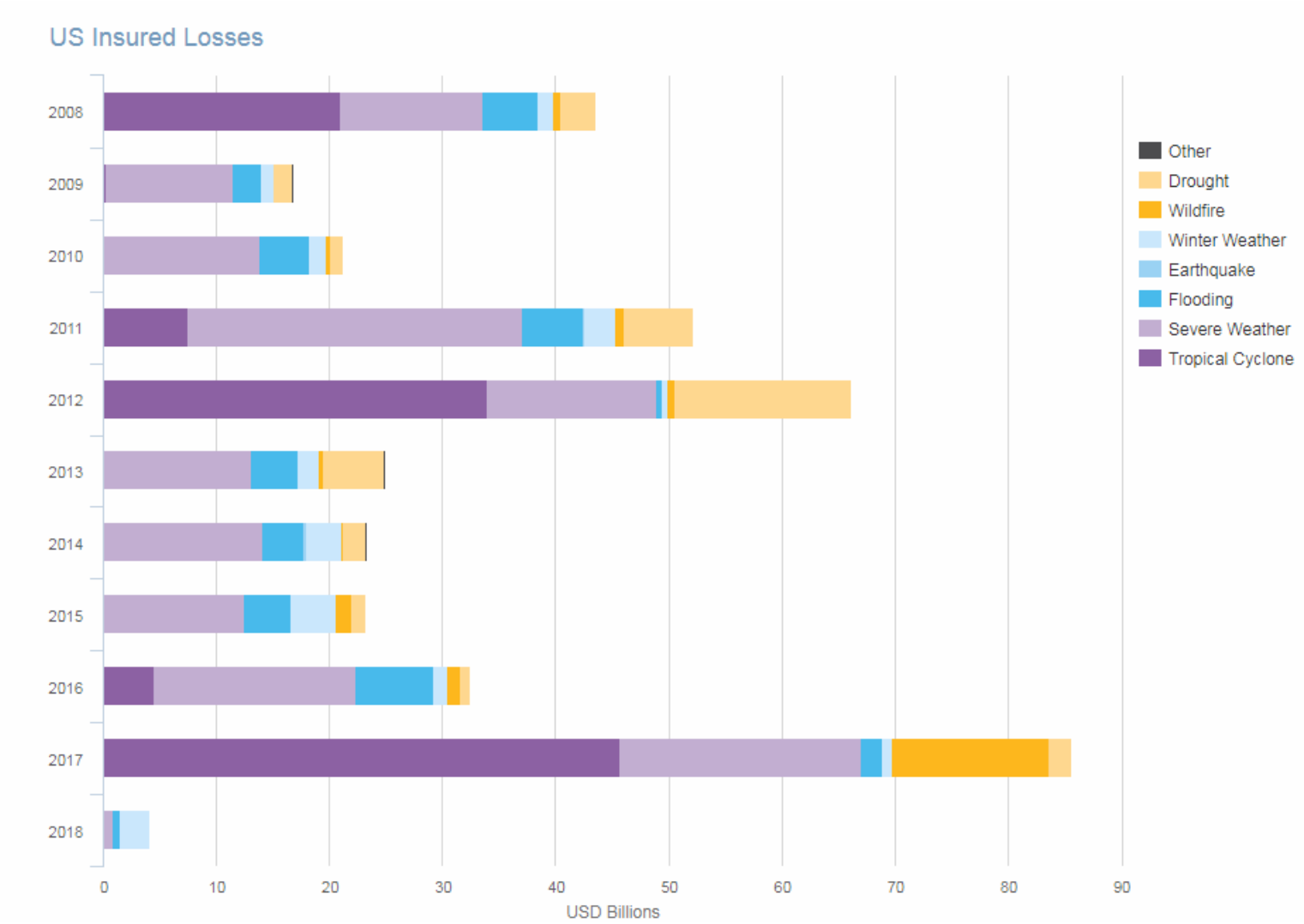
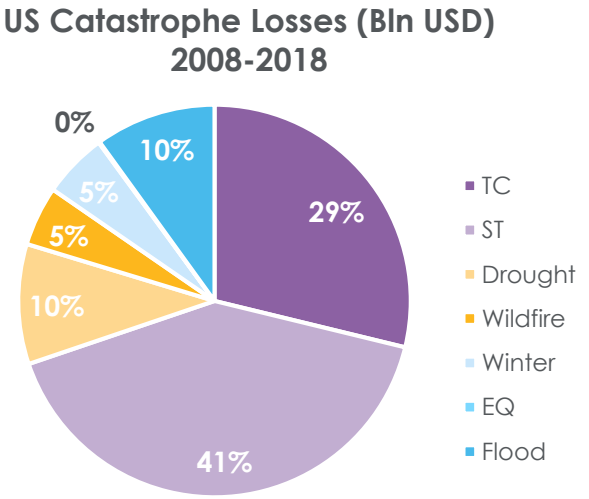
Severe Thunderstorms Losses can Rival Those Risks of More "Traditional" Concerns…



- 7/10 Years ST tops US Annual Insured Losses
- 4/10 with 15+ Billion in Loss



Source: AON Benfield Catastrophe Insight

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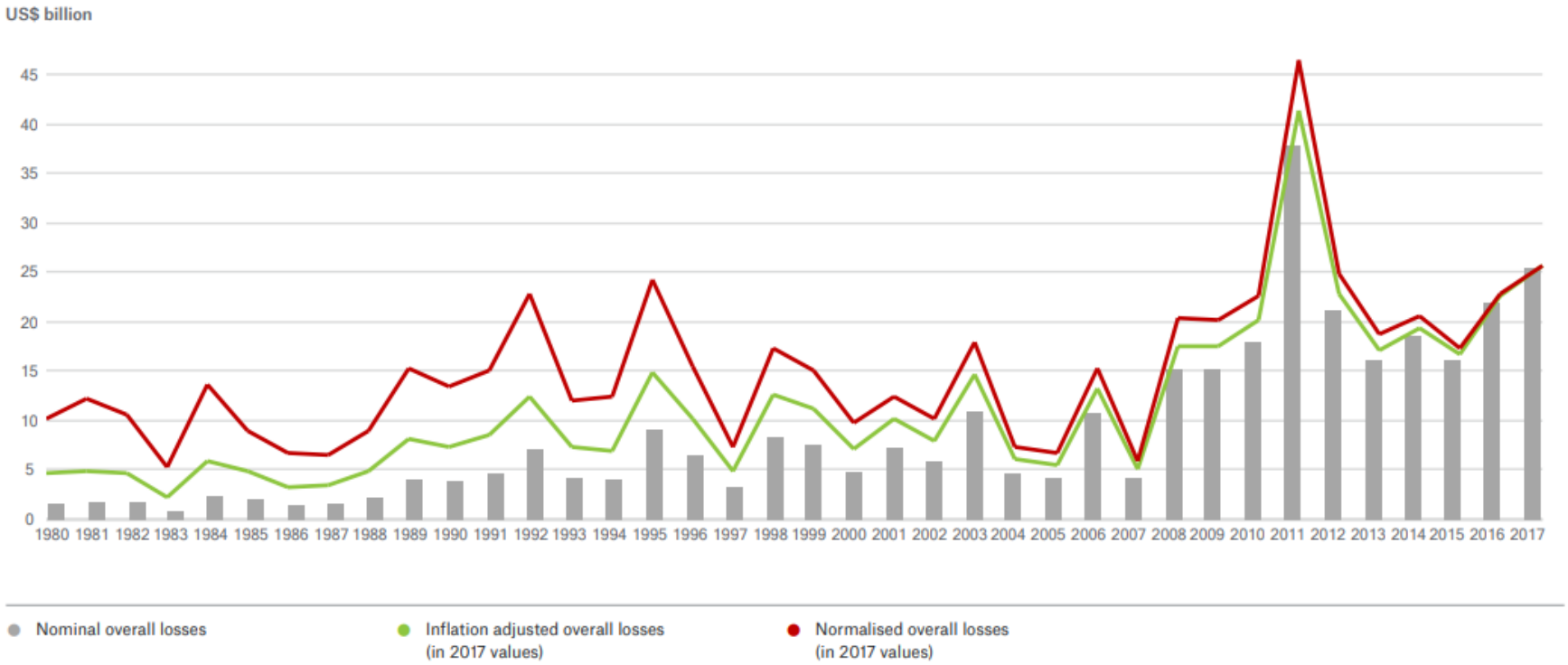
… And these Losses have Been Steadily Increasing Over the Last 30 Years

NatCatSERVICE

Munich RE

Overall losses in US$: nominal, inflation adjusted, and normalised

Relevant convective storm events
in the United States 1980 – 2017



Inflation adjusted via country-specific consumer price index and consideration of exchange rate fluctuations between local currency and US$.
Normalization via local GDP developments measured in US$.

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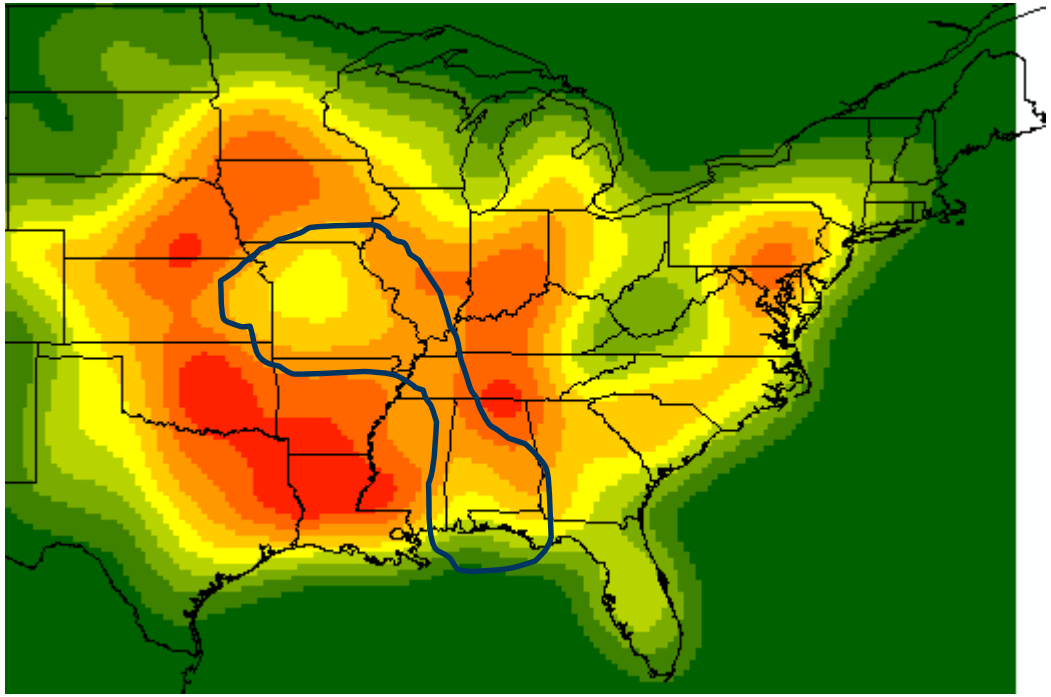
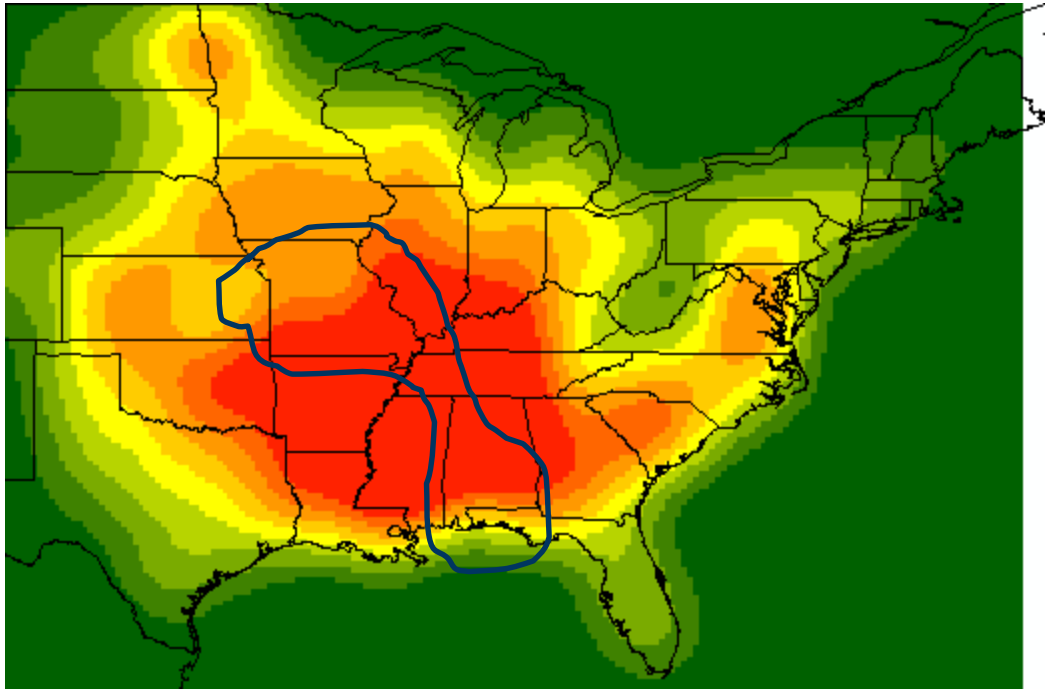
Thunderstorms Also Exhibit High Degrees of Year-to-Year Variability…

Average Annual Tornado Days
1990-2001



1.5 days — 13 days

Average Annual Tornado Days
2000-2011



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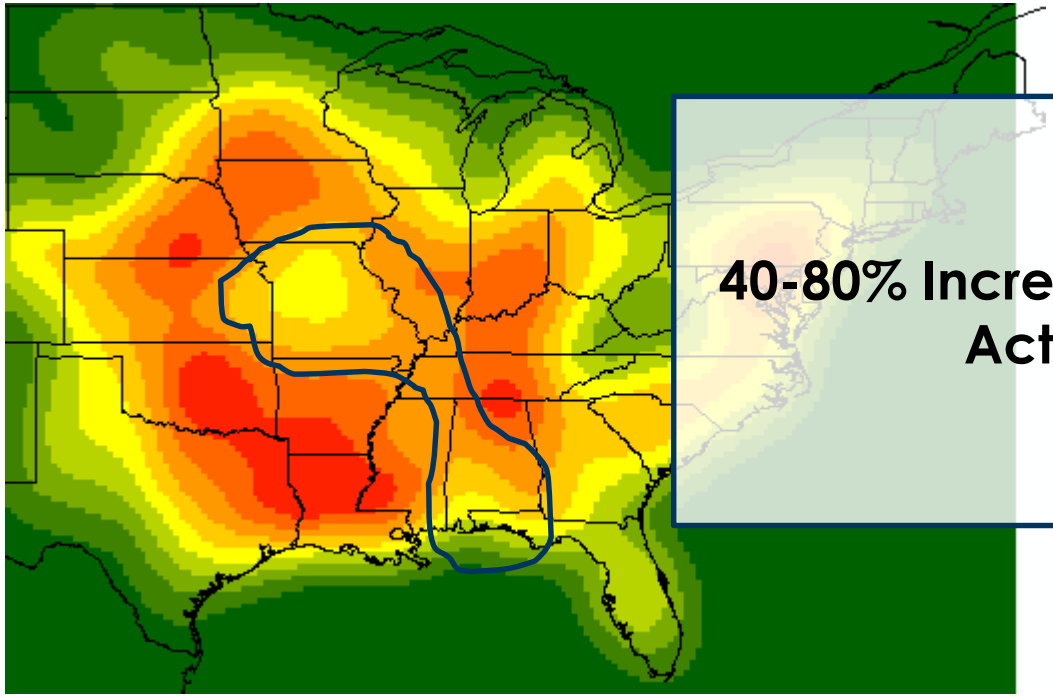
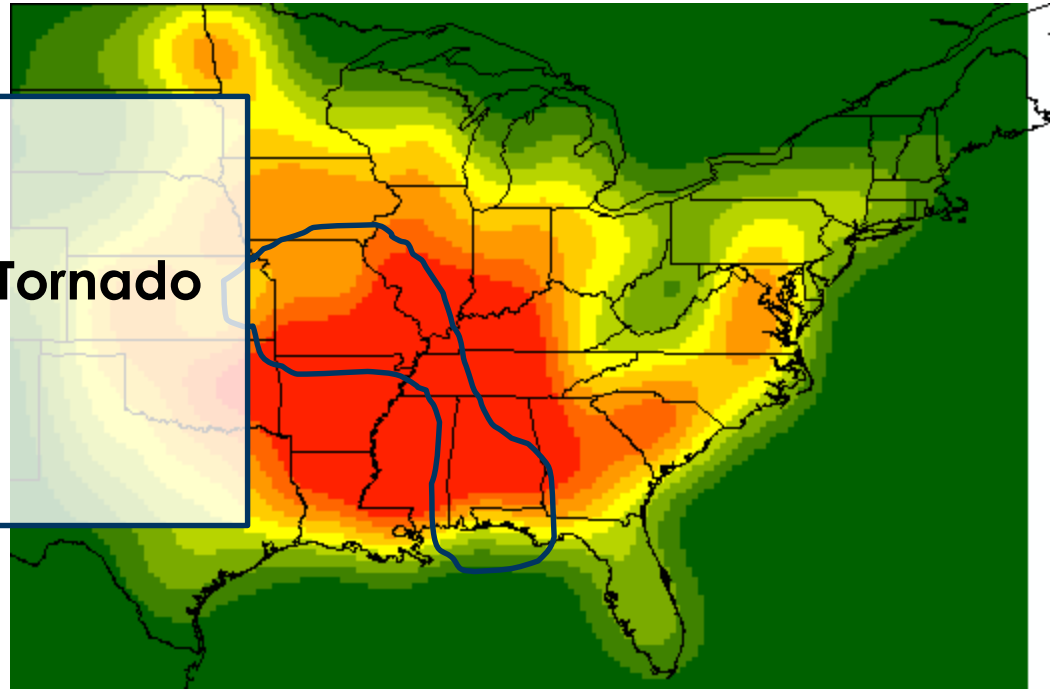


1.5 days — 13 days

40-80% Increase in Tornado Activity!!

Average Annual Tornado Days
2000-2011



1.5 days — 13 days

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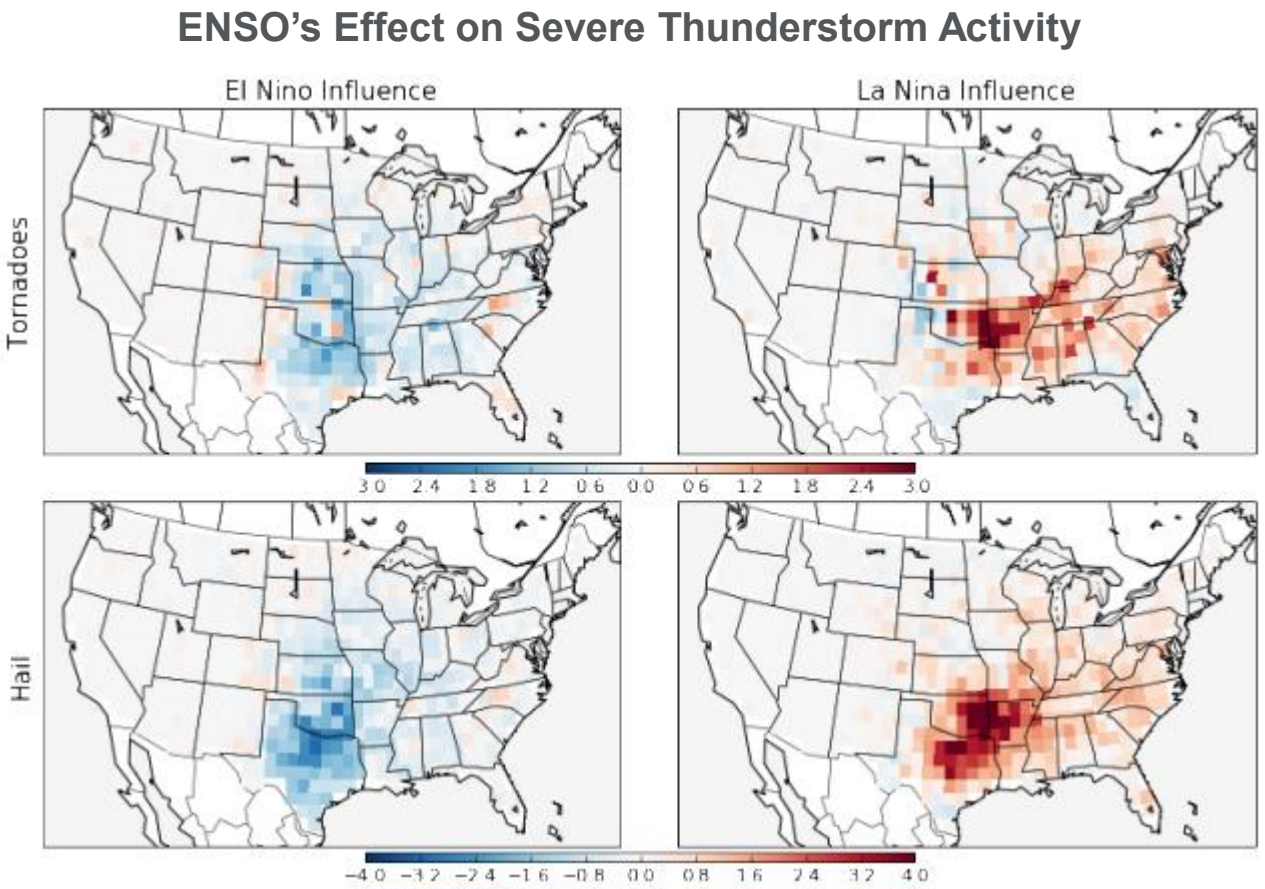
… That is Potentially Affected by Changing/Cyclical Climate Conditions



<u>But it's more than just ENSO!!</u>

Pacific Decadal Oscillation (PDO)

North Atlantic Oscillation (NAO)

Pacific-North American Pattern (PNA)

Atlantic Multi-Decadal Oscillation (AMO)

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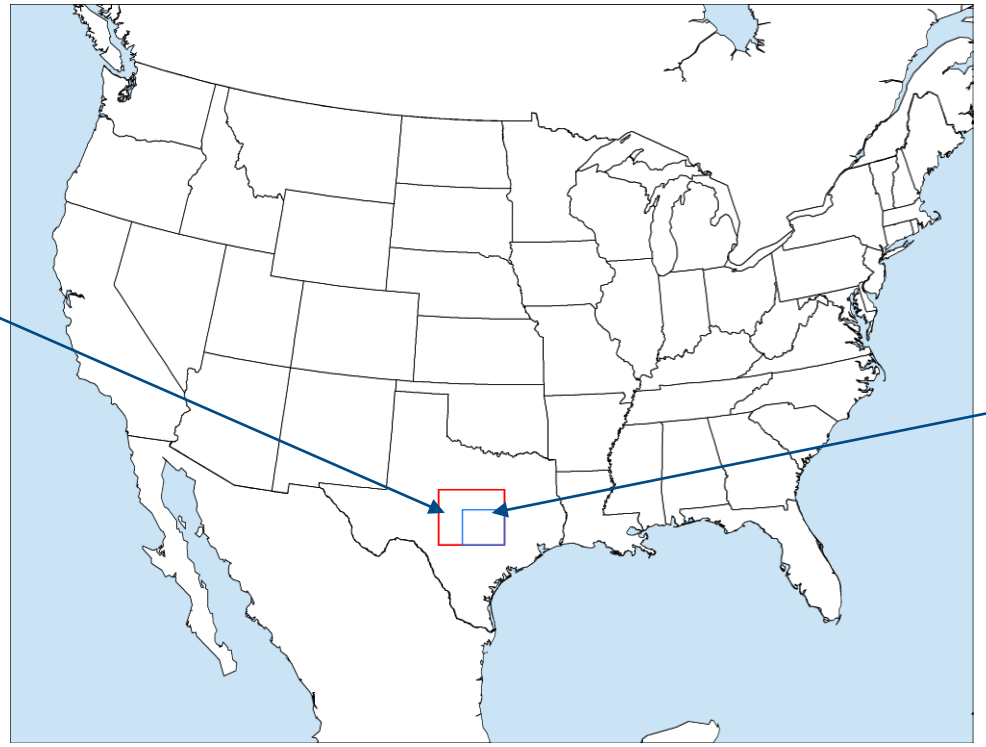
…And Covers Relatively Small Areas

If I took EVERY tornado recorded for the last 70 years, and placed them on the US without overlap:

1.3% of the Eastern 2/3 of CONUS



Limiting to the last 20-yrs and EF1+

.5% of Eastern 2/3 of CONUS

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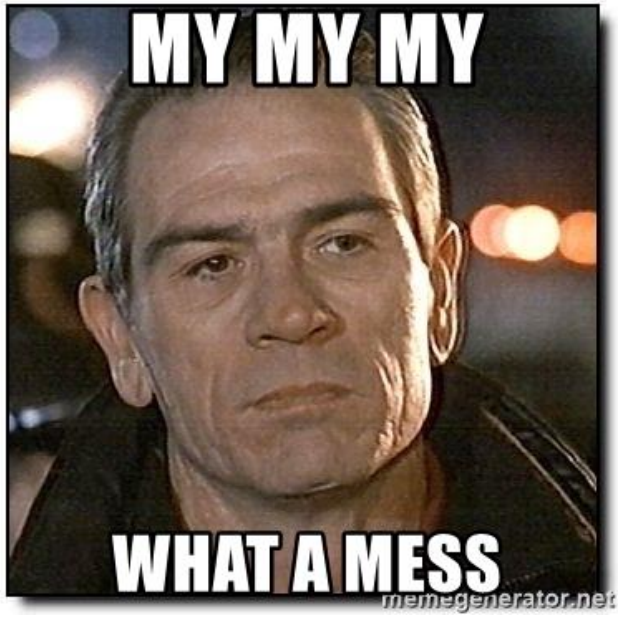
So What Does 2016-2017 (and Other Recent Years) Say About ST Risk???

- A Non-stationary, highly variable, potentially cyclical, spatially correlated, ill-observed phenomenon that can cause 10s of billions of dollars in Insured Losses per year

- In other words…



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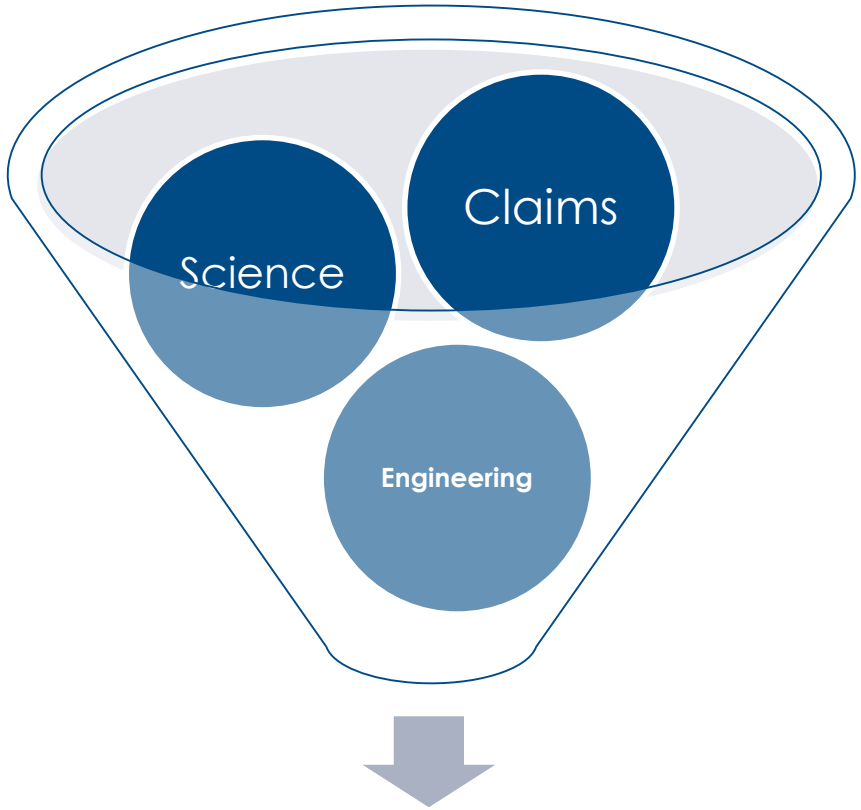
Don't Worry! The Models Can Help!



Catastrophe Models

- Leverage multiple datasets to extend our "observational" dataset
  - Helps reduce variability and uncertainty
- Leverage engineering and science to differentiate risks in a robust way
- Test sensitivities to various parameters (e.g. missing data)

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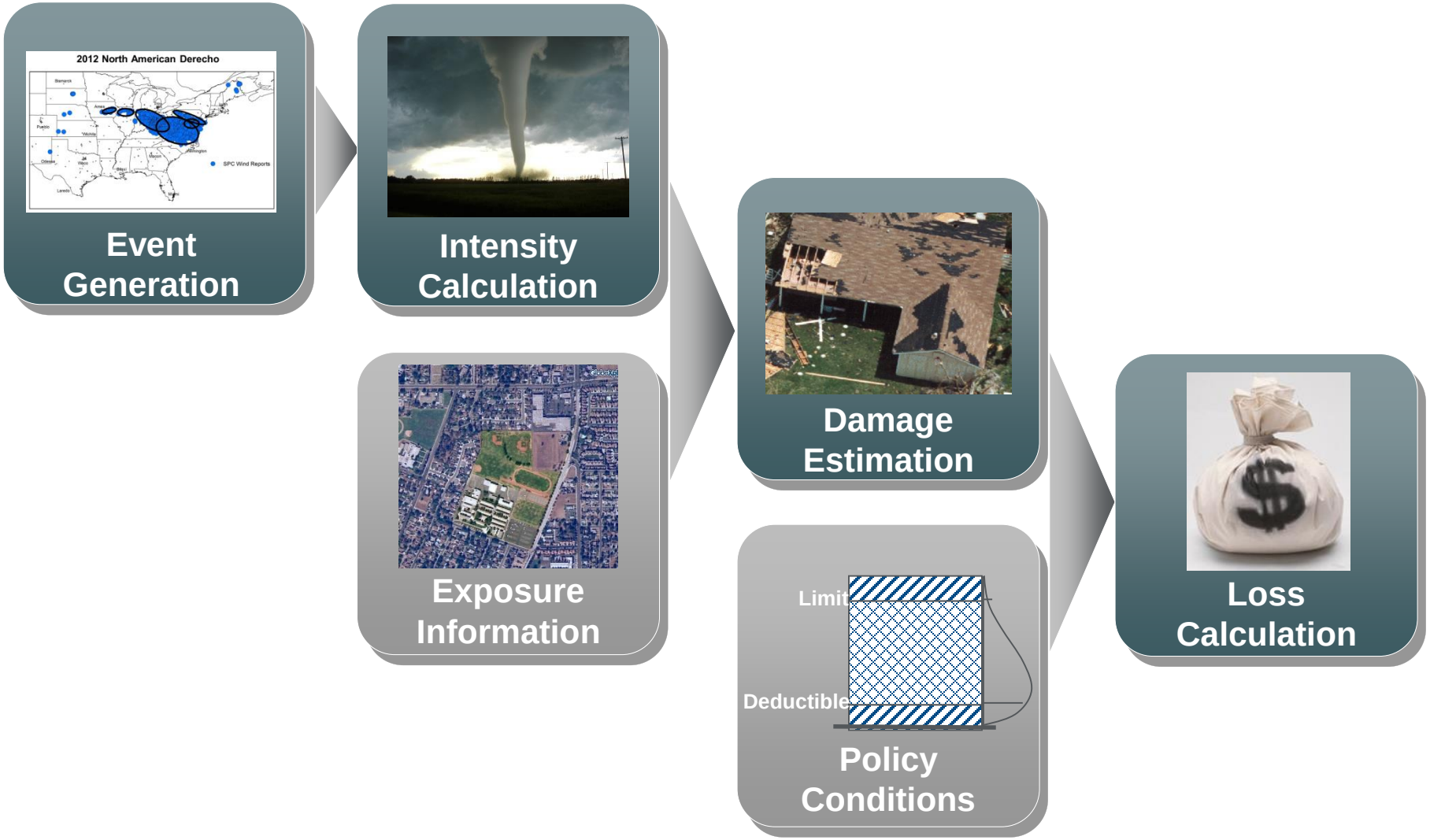
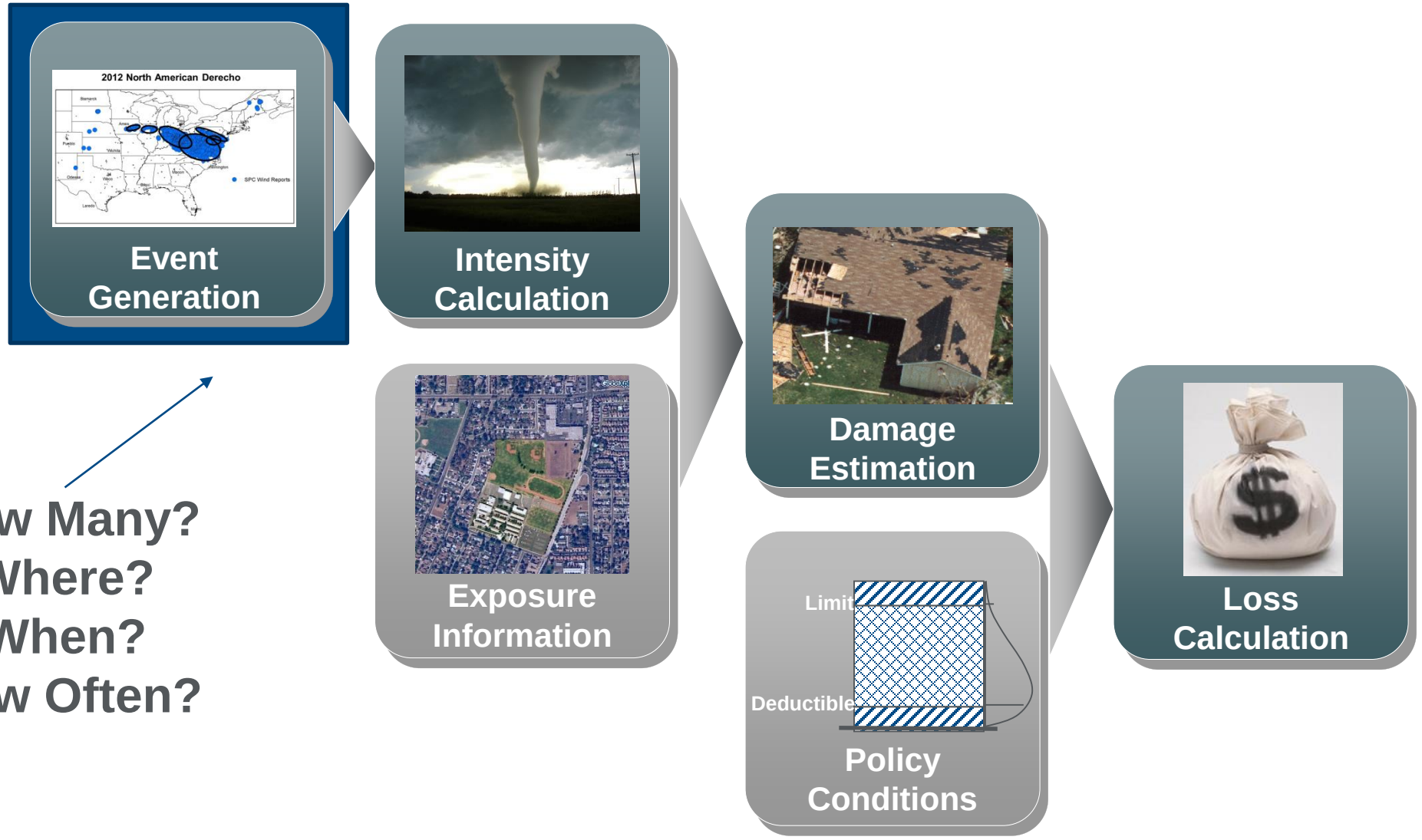
The Basic CAT Modeling Framework



The Basic CAT Modeling Framework



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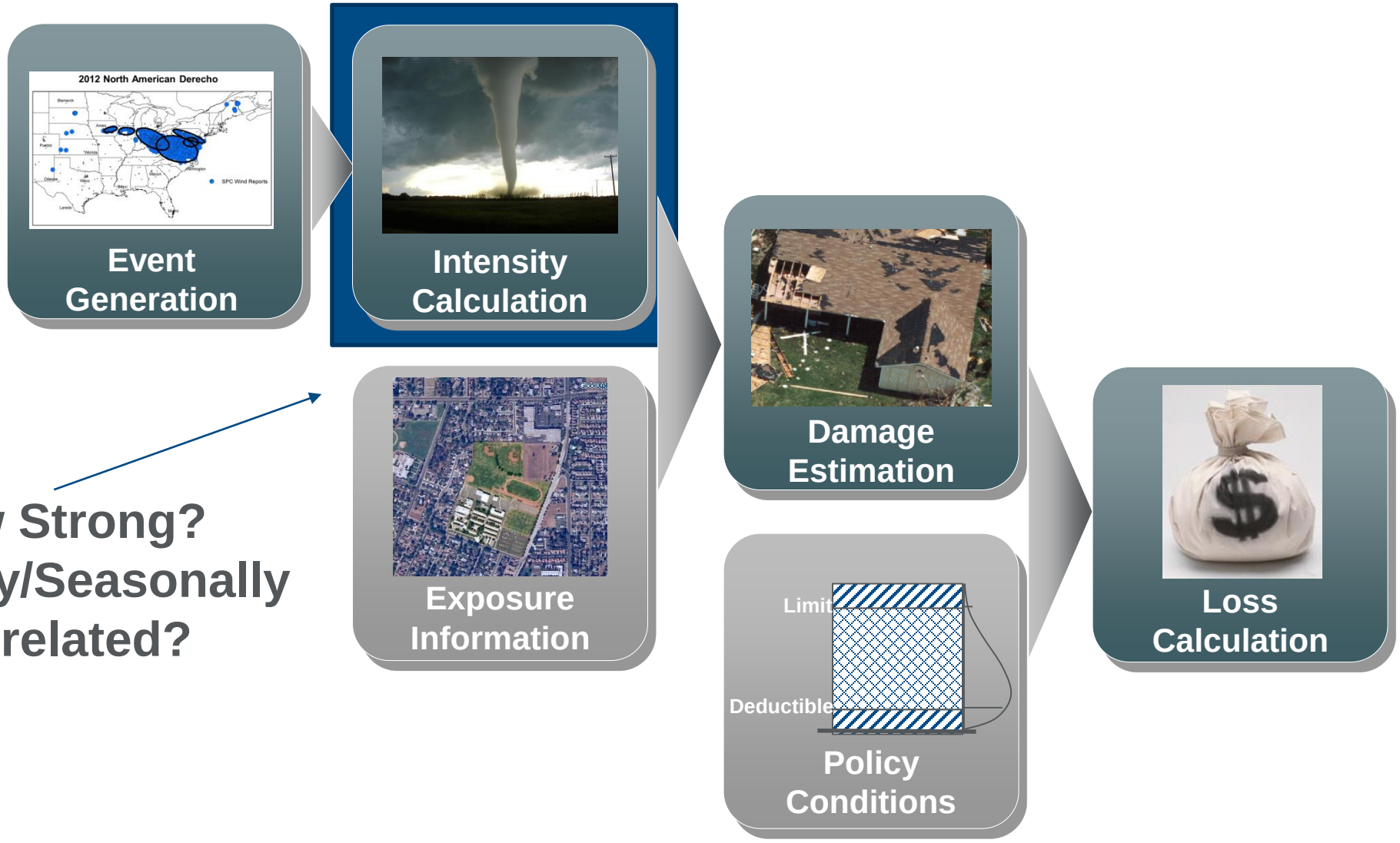

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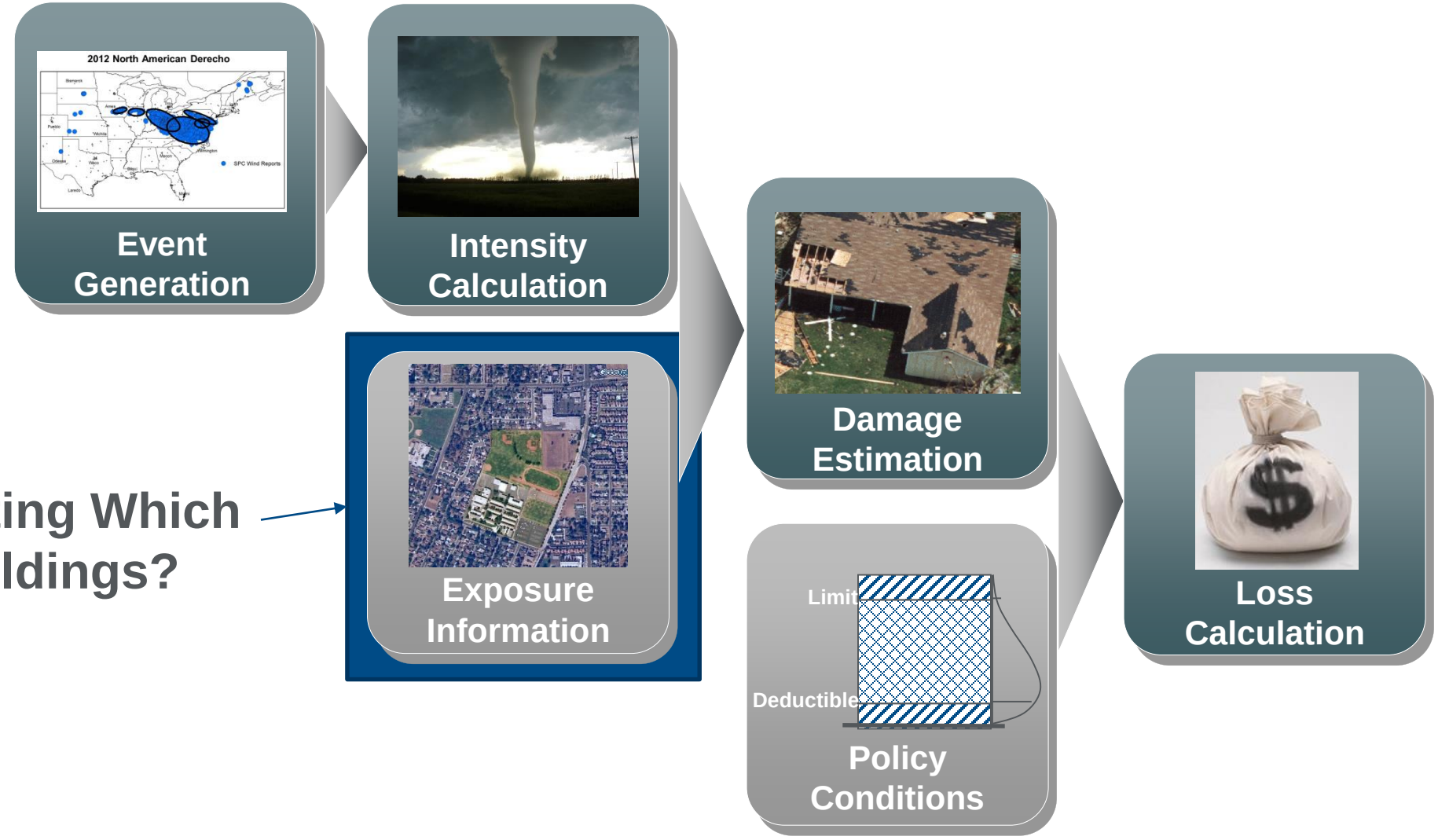

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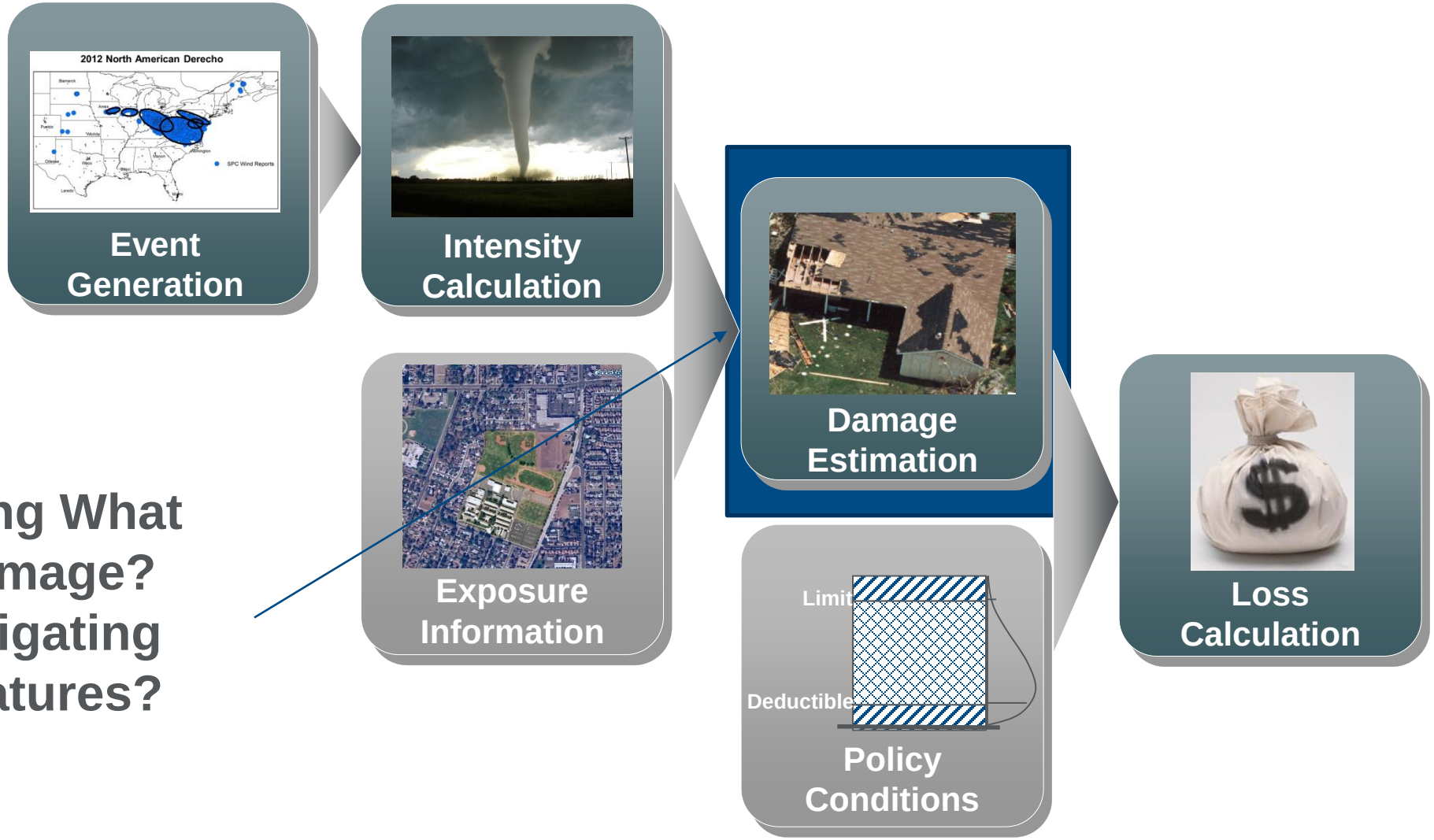
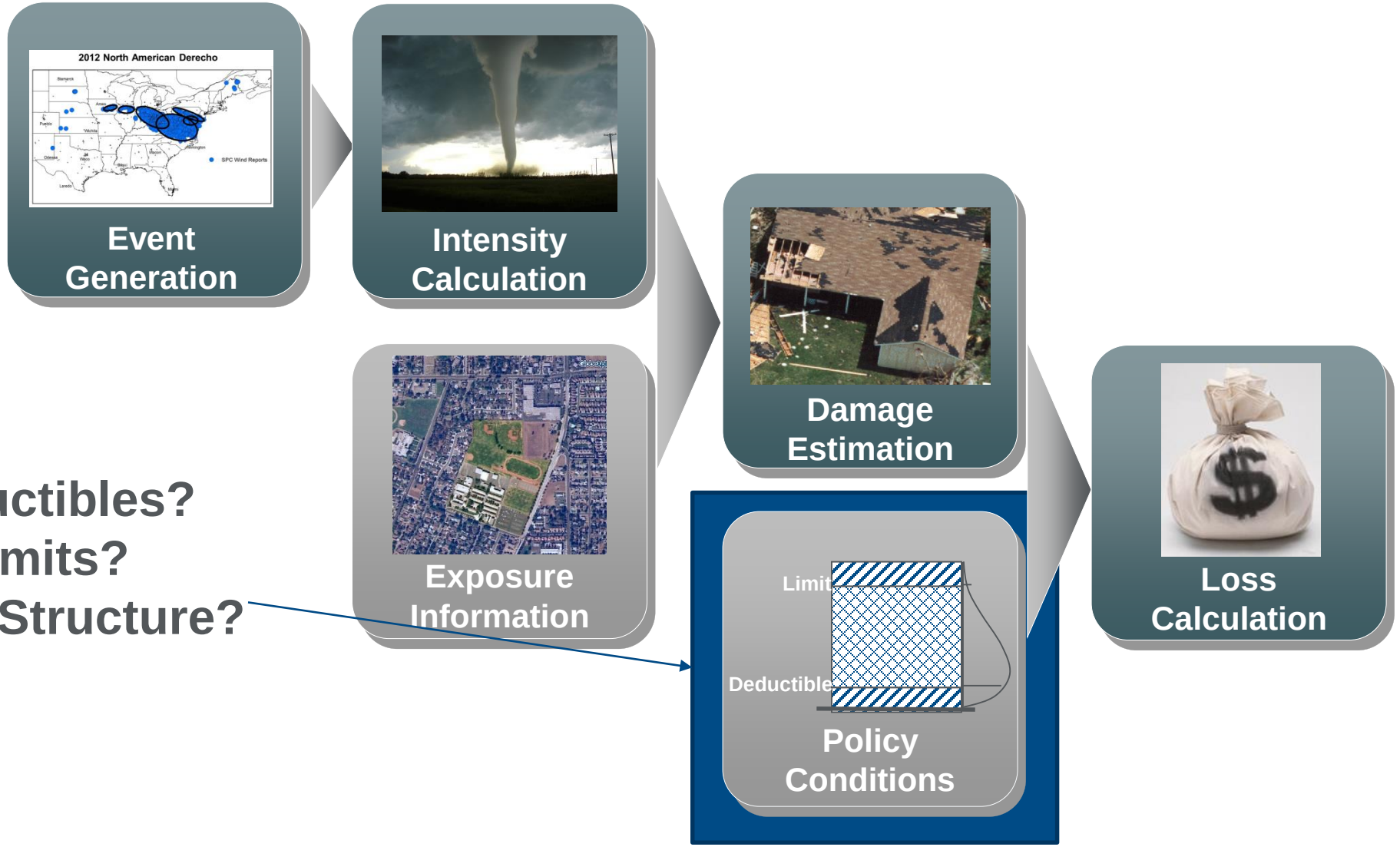


Doing What Damage? Mitigating Features?

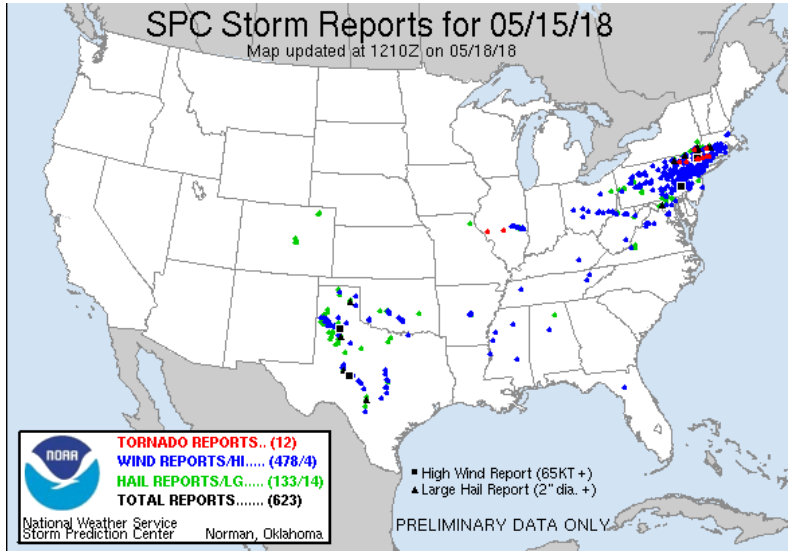
The Basic CAT Modeling Framework



The Basic CAT Modeling Framework

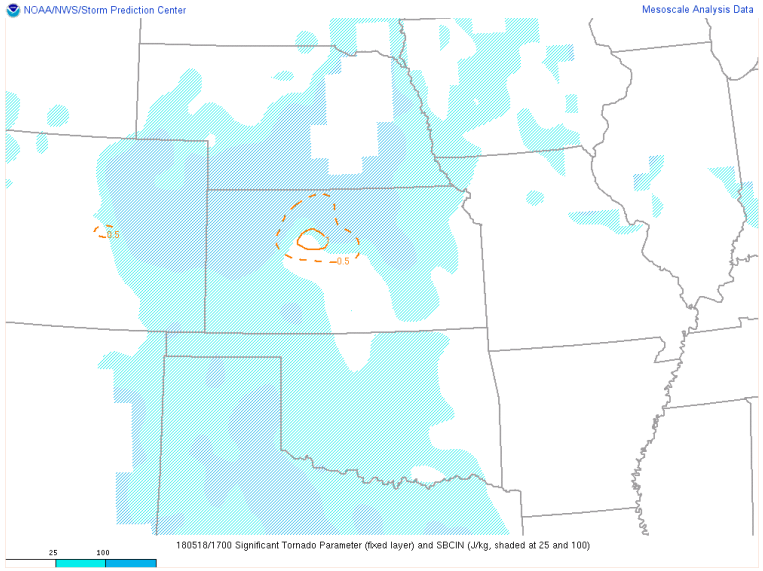
Event Generation: What Data Sources Do We Have to Quantify the Risk?

Eye-witness Reports



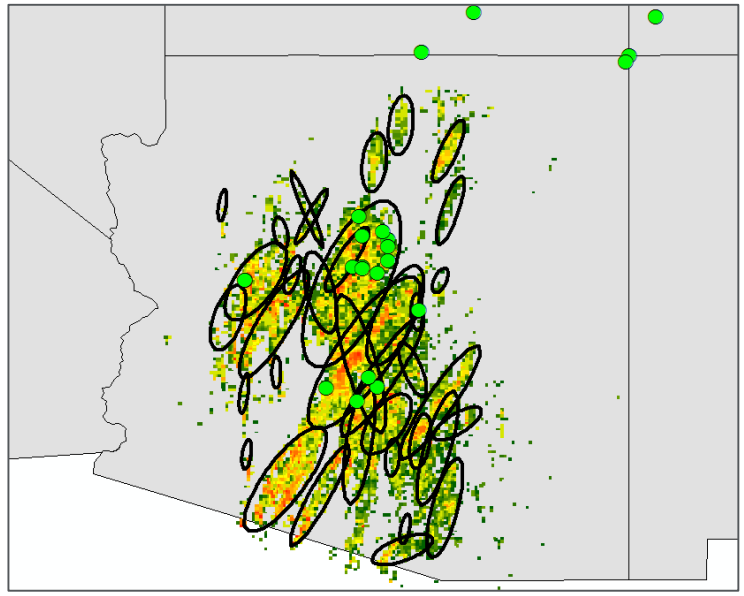
Ground "Truth" But Biased by Population Changes

Weather Data



Temperature, Humidity, Wind Speed BUT TYPICALLY not specific to wind/hail/tornado

Other Datasets (e.g. Radar)



Depends on time and space coverage. Uncertainties vary by data type

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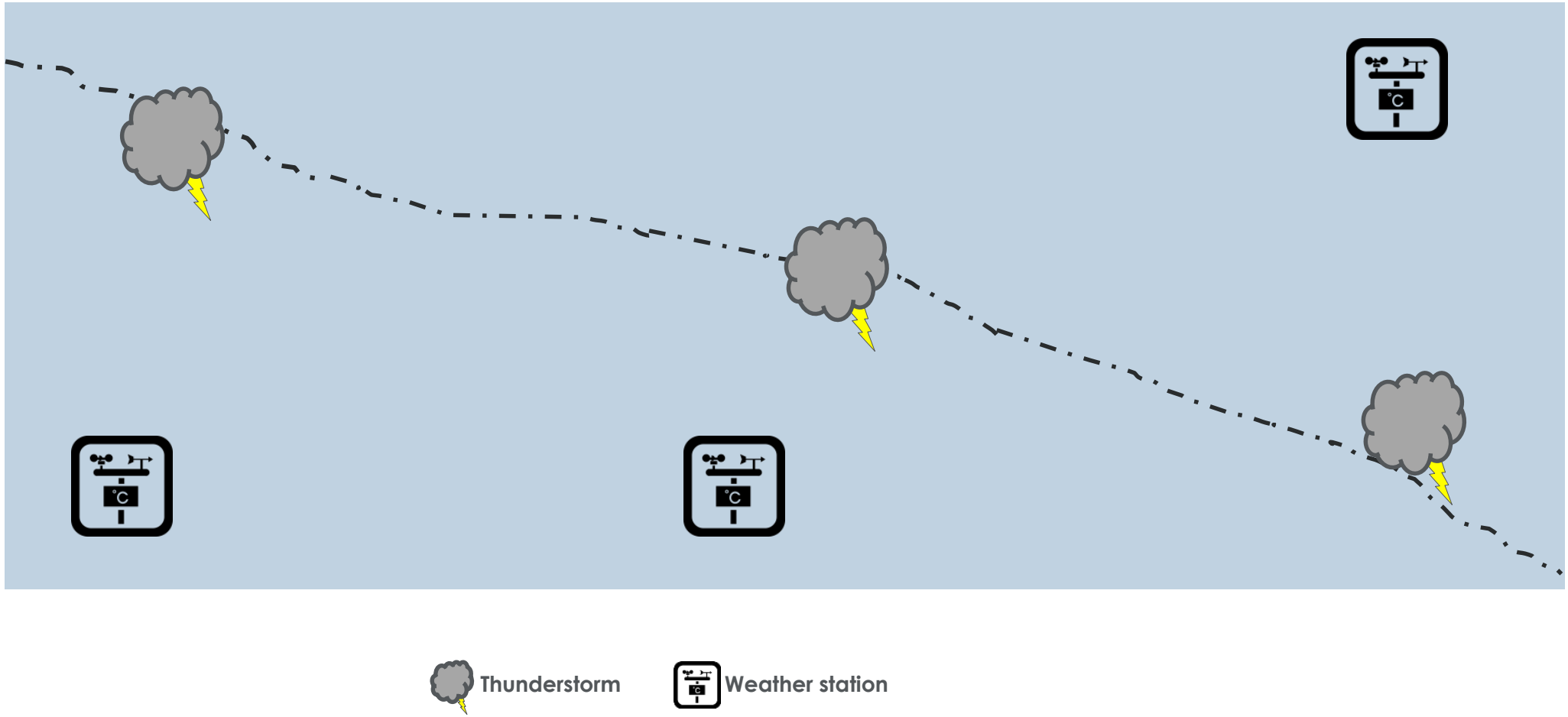
Scale of Storms Makes Them Difficult to Observe



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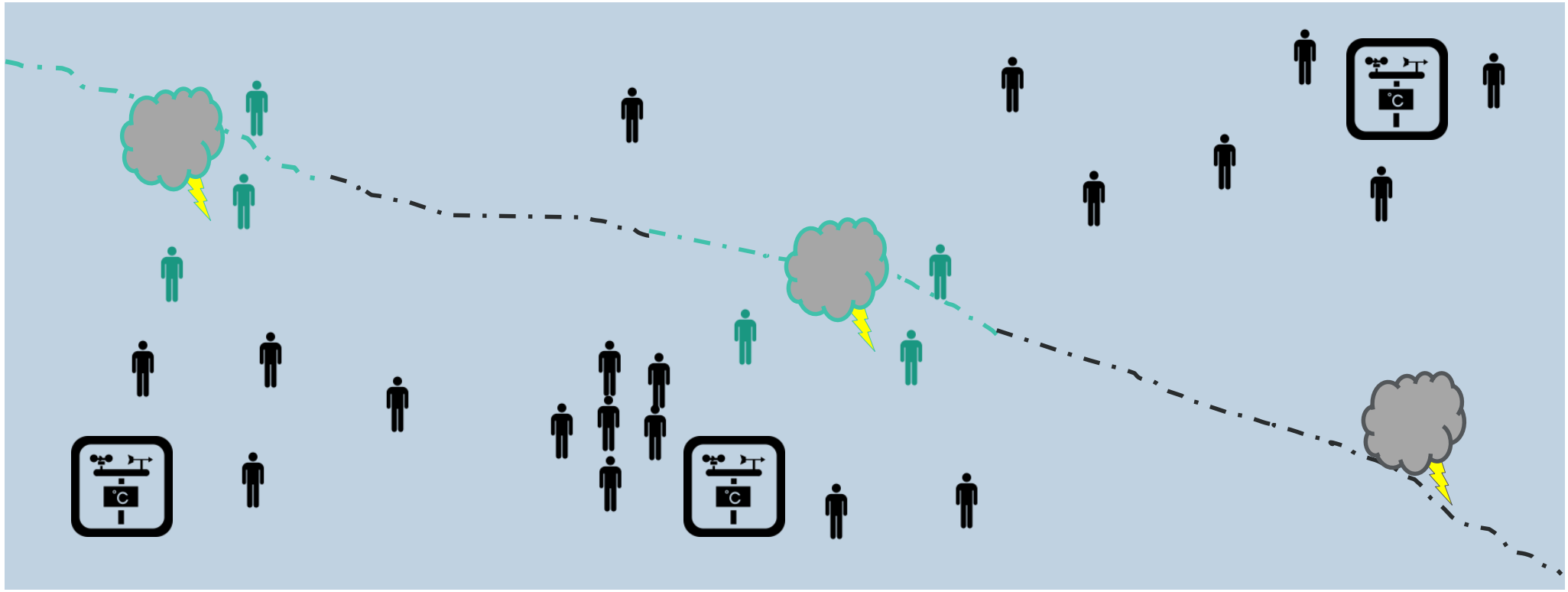

Thunderstorm Weather station Observer

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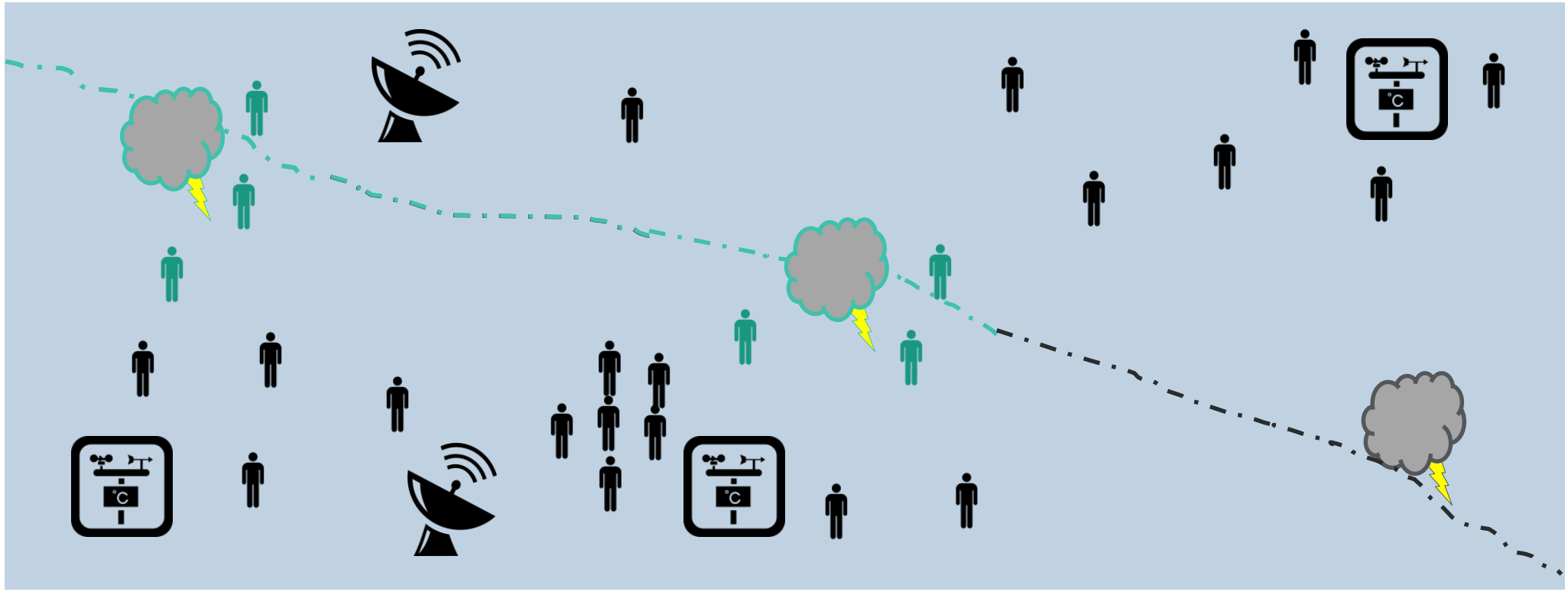
Scale of Storms Makes Them Difficult to Observe



Radar Thunderstorm Weather station Observer

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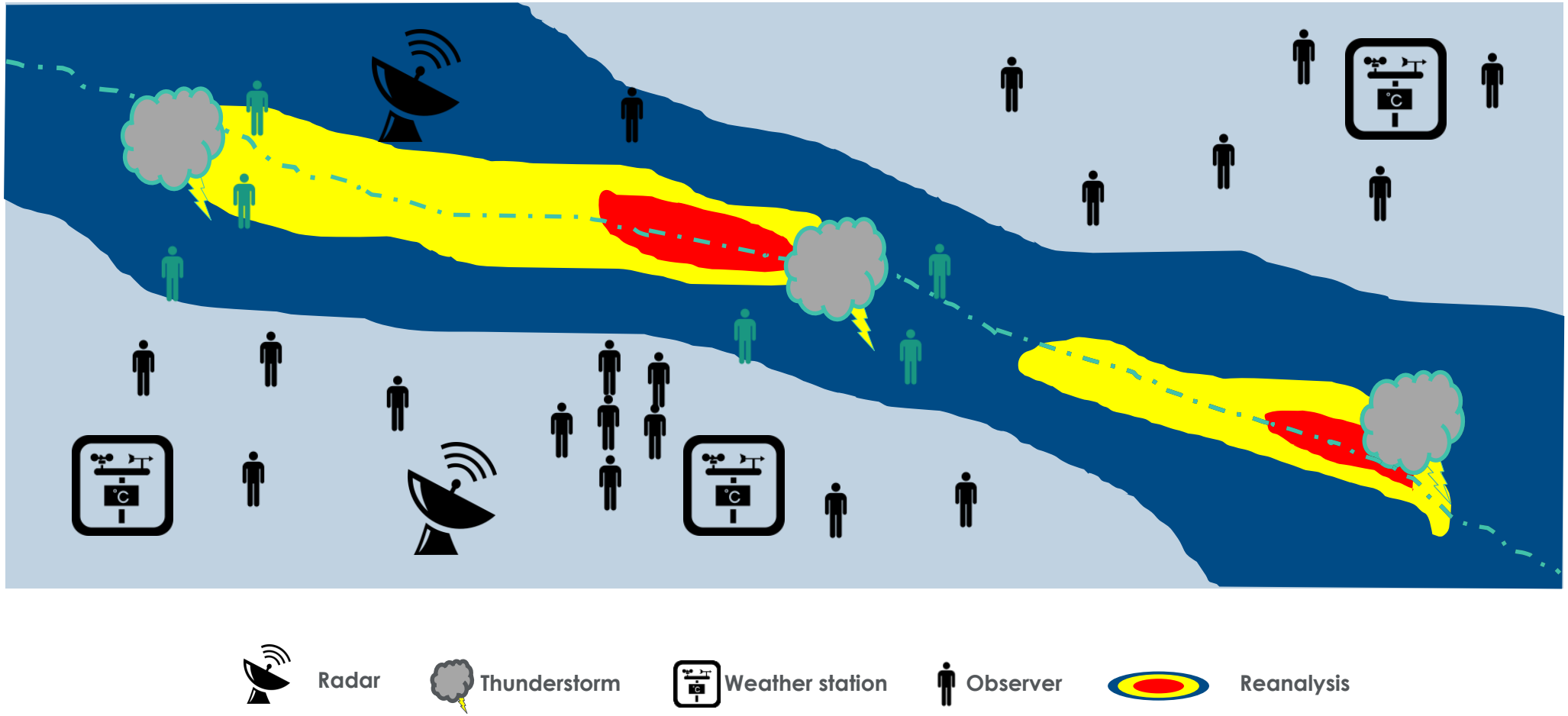
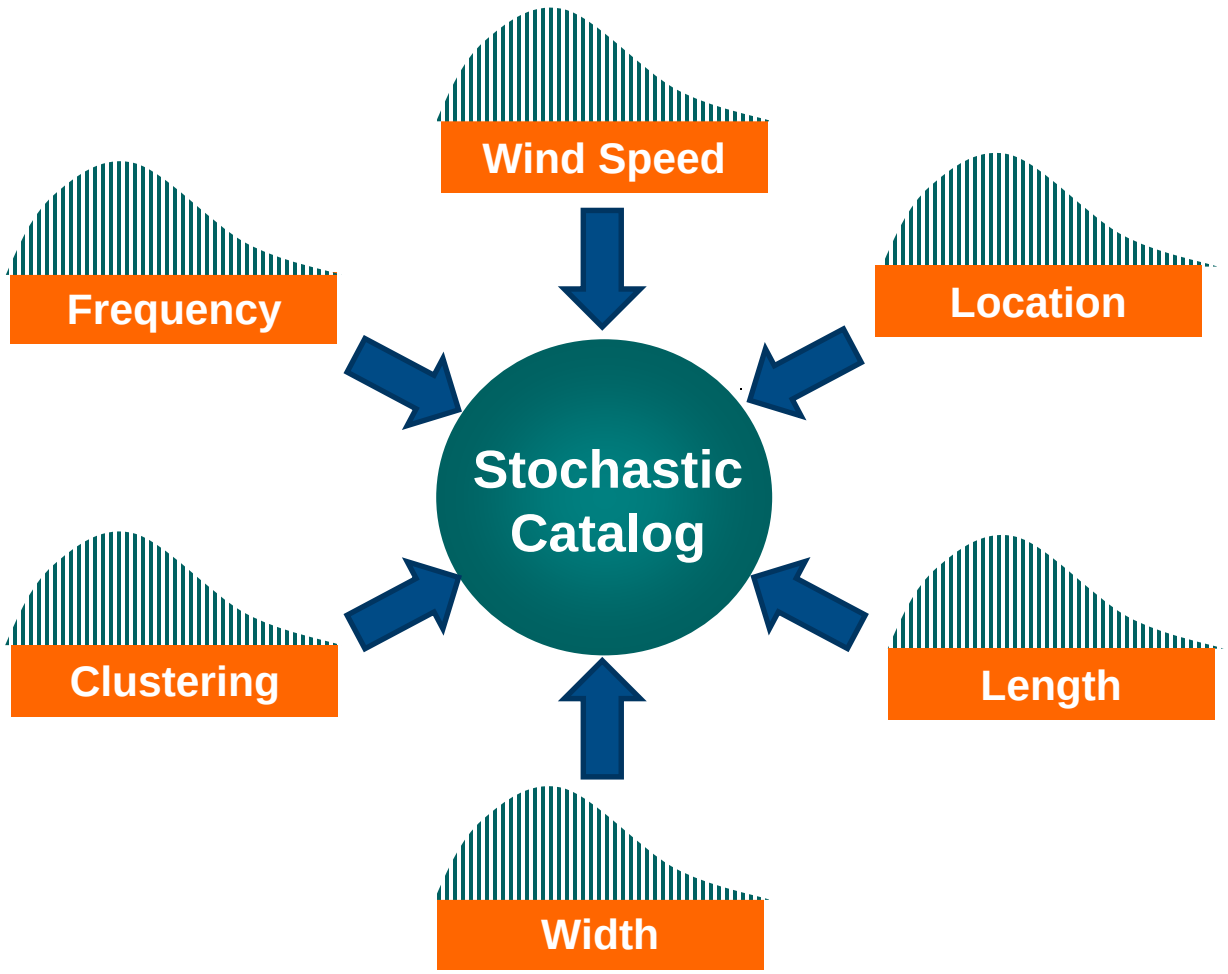
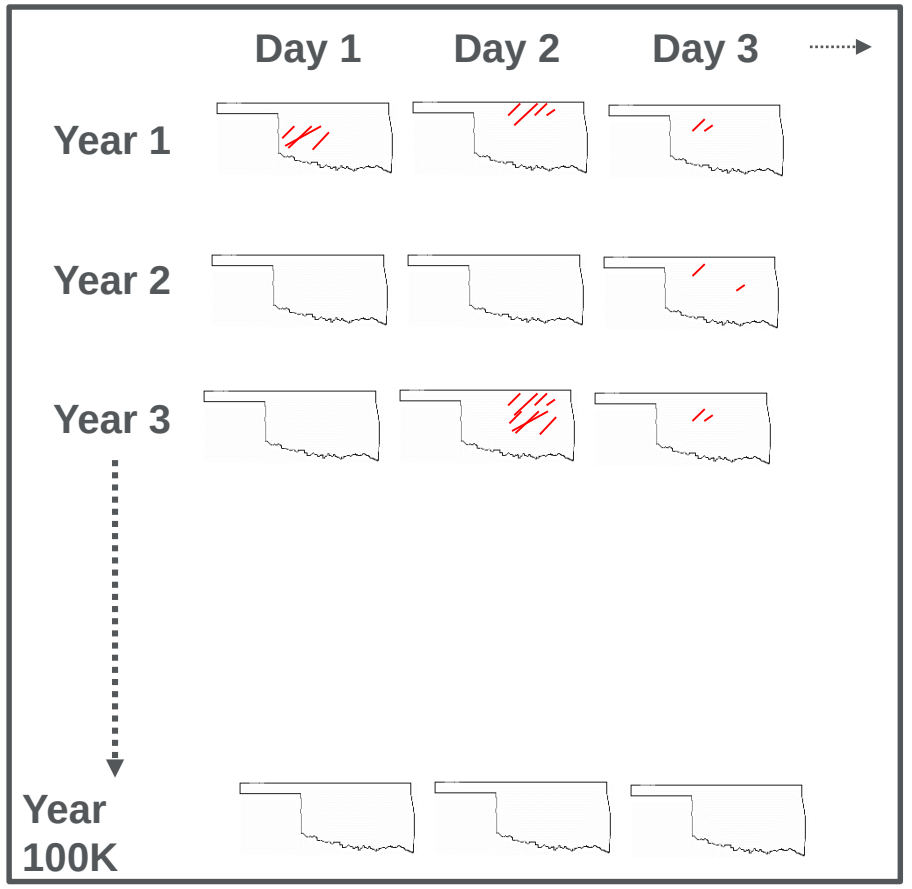
Scale of Storms Makes Them Difficult to Observe



These Datasets Combine to Provide a Catalog of Plausible, Yet Perhaps Yet Unrealized Events



A 100K Year Stochastic Catalog



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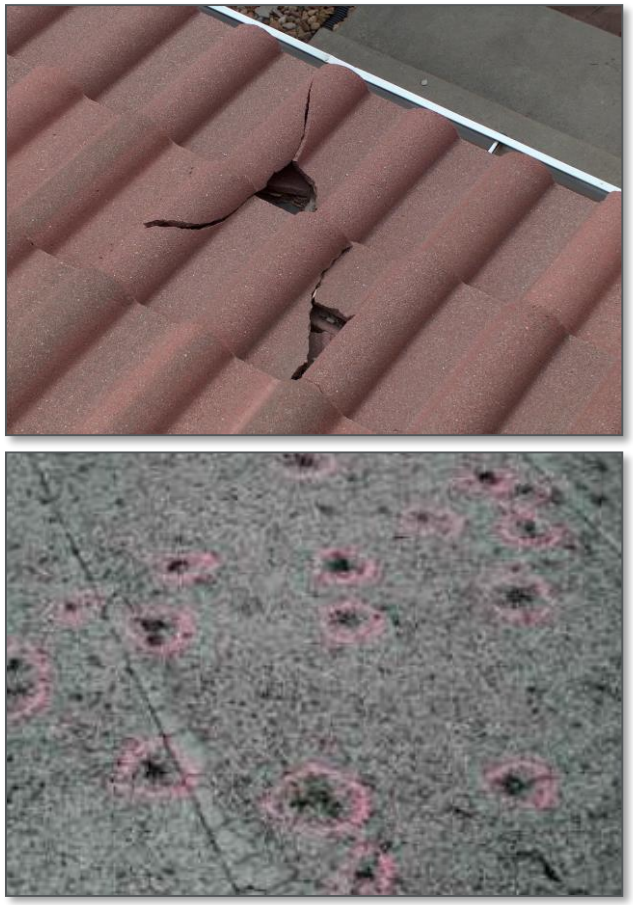
Now that We Have a Catalog… How Do We Calculate Damage?

Experiments

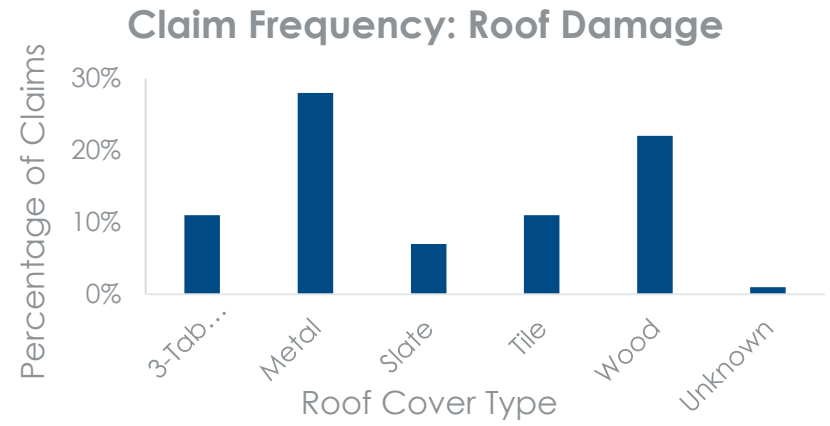
Source: Marshall et al., 2002

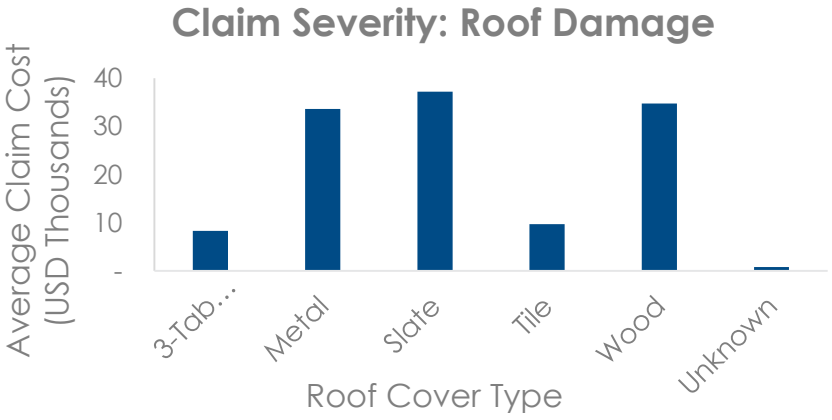
Damage Surveys



Source: RICOWI & AIR Damage Surveys

Claims Studies





Source: IBHS, 2013

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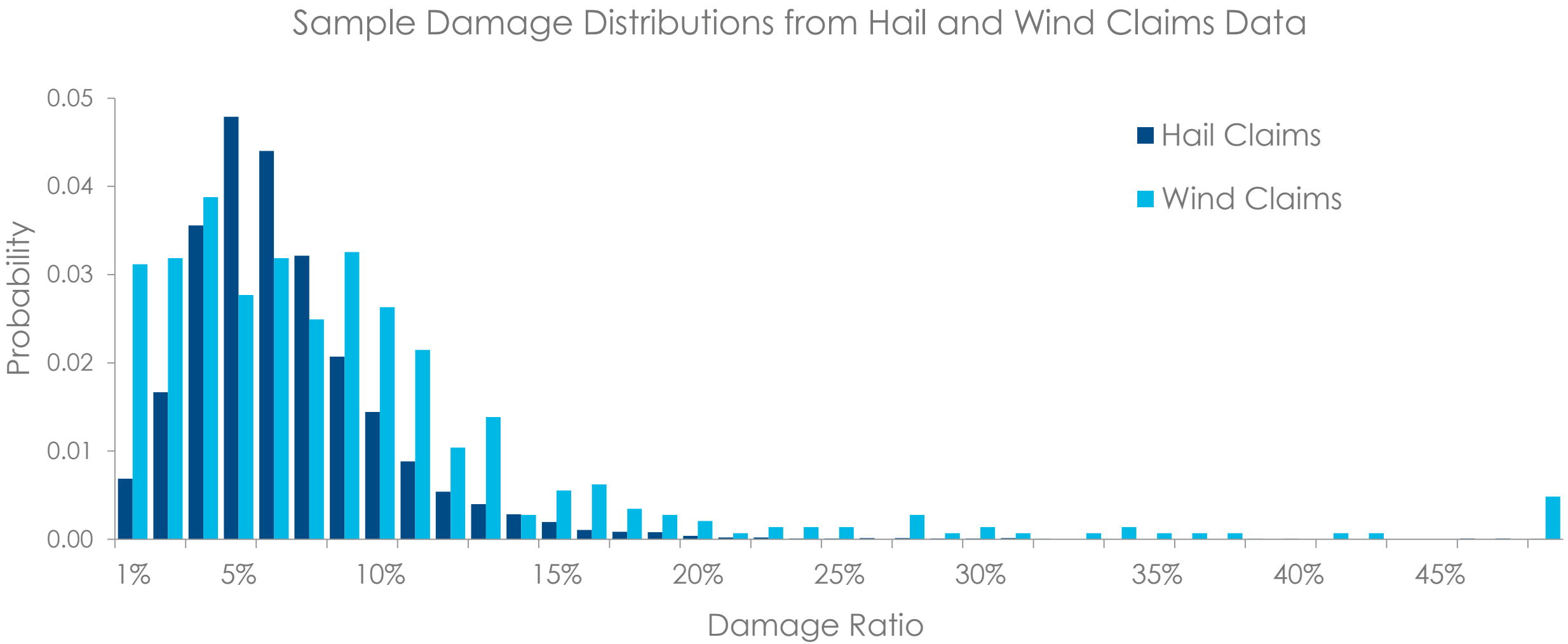
We Can Also Understand Uncertainty Directly Using Claims Data



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In Fact These Data Sources Allow Us to Consider Many Different Mitigation Factors?

Supported Features in the Severe Thunderstorm Model	
• Seal of Approval	• Roof Anchorage
• Floor of Interest	• Year Roof Built
• Building Condition	• Wall Type
• Tree Exposure	• Wall Siding
• Small Debris Source	• Glass Type
• Large Missile Source	• Glass Percent
• Terrain Roughness	• Window Protection
• Adjacent Building Height	• Exterior Doors
• Roof Geometry	• Building-Foundation Connection
• Roof Pitch	• Internal Partition Walls
• Roof Covering	• Wall Attached Structures
• Roof Deck	• Appurtenant Structures
• Roof Covering Attachment	• Roof Attached Structures
• Roof Deck Attachment	

Newly Added Features ONLY for Hail	Hail Impact Resistance Roof Coverings:	
	✓ Class A	Least resistant
	✓ Class B	
	✓ Class C	
	✓ Class D	Most resistant

Note: Secondary features highlighted in green are supported for the hail sub-peril.

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Damage Estimation: Translate Exposure, Building Characteristics, and Hazard into Damage

Building Characteristics

Roof Cover Type

+

Roof Slope

+

Wall Siding

+

...

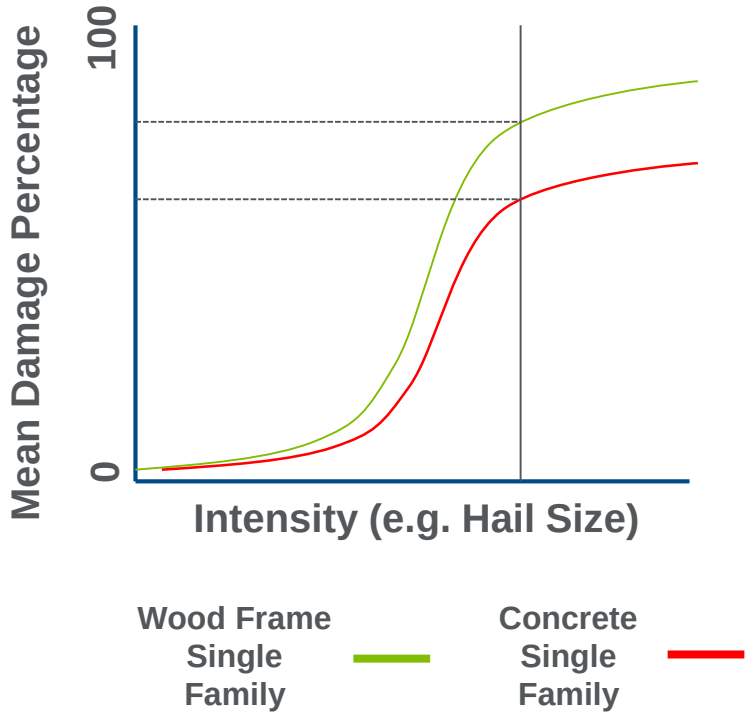
→ Hail Vulnerability

Lab Tests

In-Situ Measurements

Engineering Principles

Damage Functions



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Loss Estimation: Apply Policy Terms and Uncertainty to Get Total Gross Insured Loss

Hazard

Vulnerability

Exposure

=

Ground Up Loss

+

Policy Terms

- Limits
- Deductibles
- Reinsurance
- Uncertainty

Gross Loss

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So How Can We Use This Tool to Manage the "Mess"?

The model alleviates many of the previous issues we encountered:

- **"Highly variable"**
  More "years" of data allow for decreased variance and increased coverage
- **"Ill-observed"**
  Application of meteorology and engineering allows for reasonable estimates in absence of claims data
- **"Non-stationary, spatially correlated, and potentially cyclical"**
  Climate variability implicitly captured through use of historical atmospheric conditions

The model also allows us to answer key questions like…

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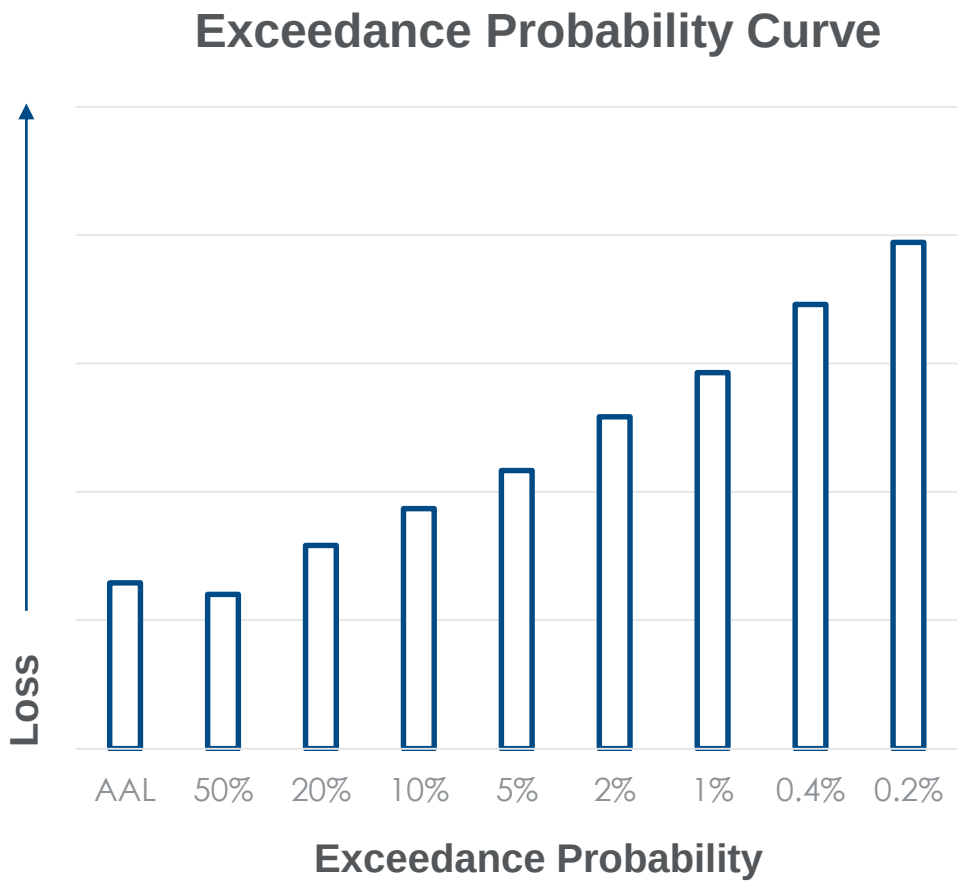
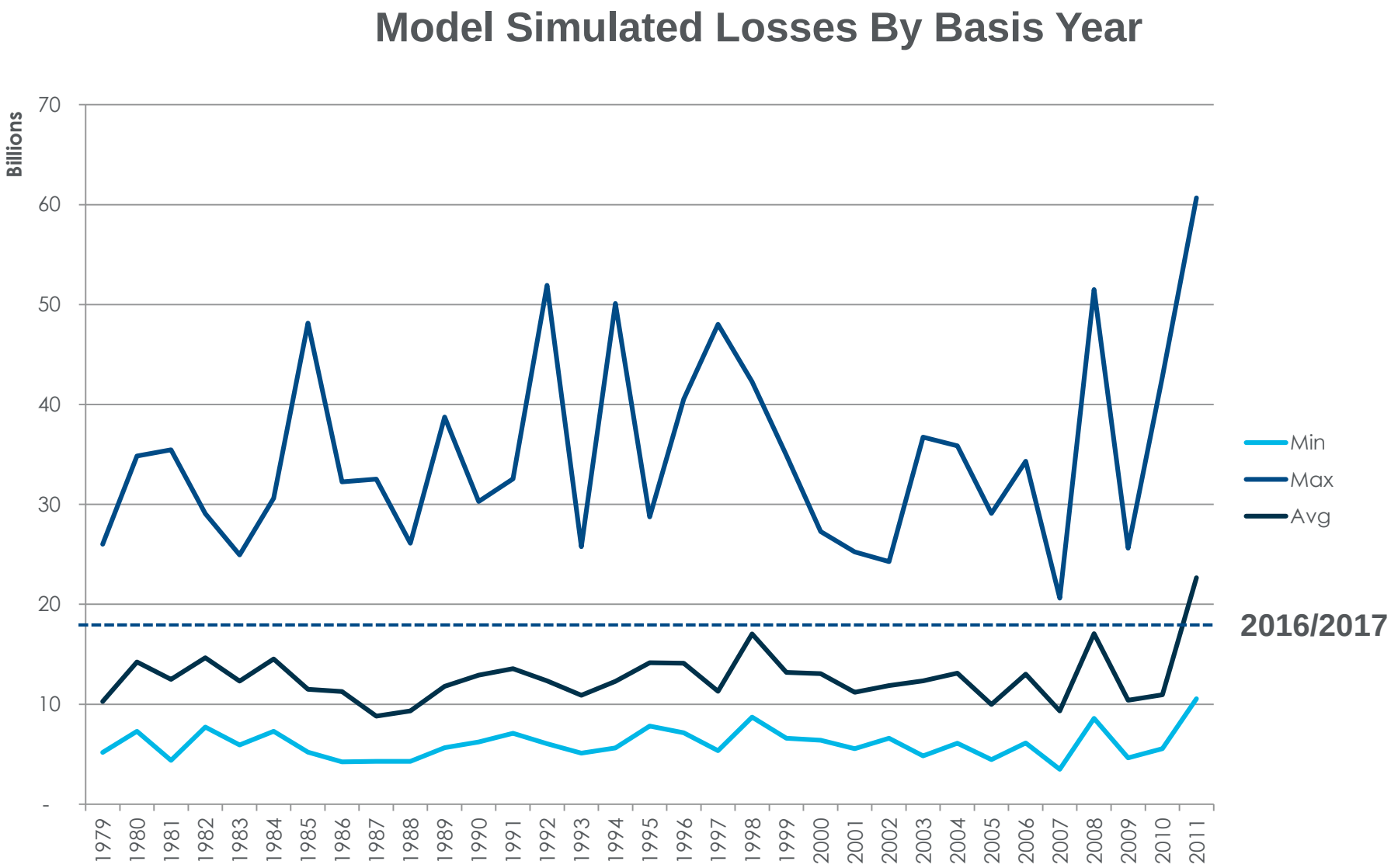
"What was the Probability of that Happening?!"

Event Loss Table

Event ID	Year	Month	Day	Loss
1	1	5	28	2,153,555
2	1	6	3	75,000,000
3	1	6	27	43,023,654
…	….	…	…	…
…	….	…	…	…
…	….	…	…	…
…	….	…	…	…
53229	10000	10	1	100,235,225
53230	10000	11	12	5,237,585
53231	10000	12	15	10,236,125

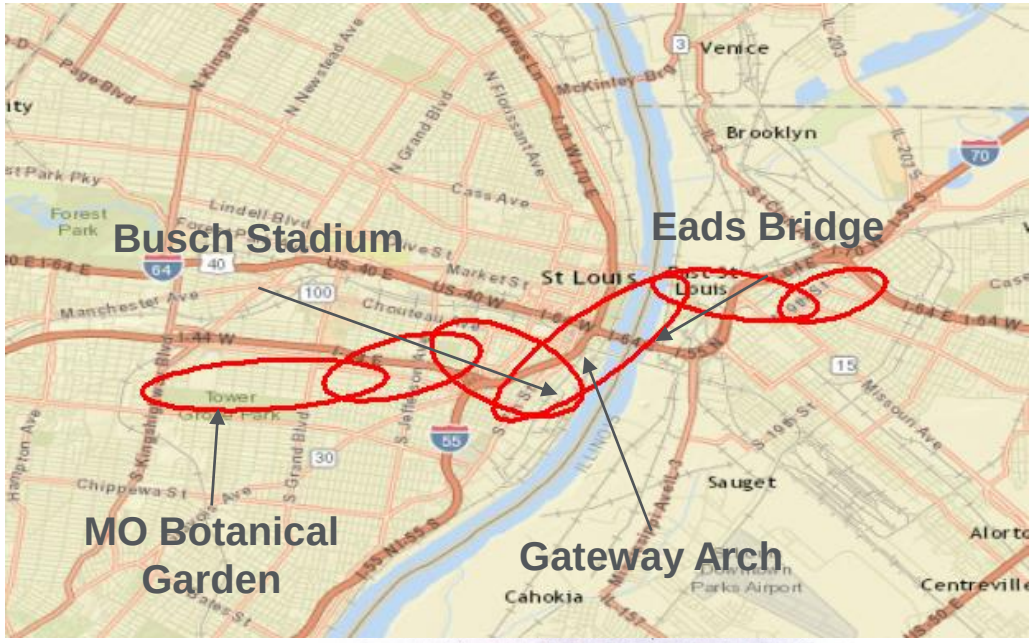


"How Much of an Outlier was 20XX?



"What if it happened again!?"

1896 St. Louis Tornado



St. Louis c. 1875

St. Louis – Present Day

Method	Rate/yr	Loss 2014
Inflation Only	3.3%	$ 543,653,610
GNP	4.9%	$ 3,558,163,038
Tangible Wealth	6.3%	$ 15,976,856,168
Modeled	**N/A**	**$ 7,256,136,150**

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The Case for CAT Models…

Severe thunderstorms present a complex yet serious risk to the insurance market

CAT model's help "tame the mess"

Flexibility and robustness help view the risk from different perspectives

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