That Cost Me What!?

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

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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)

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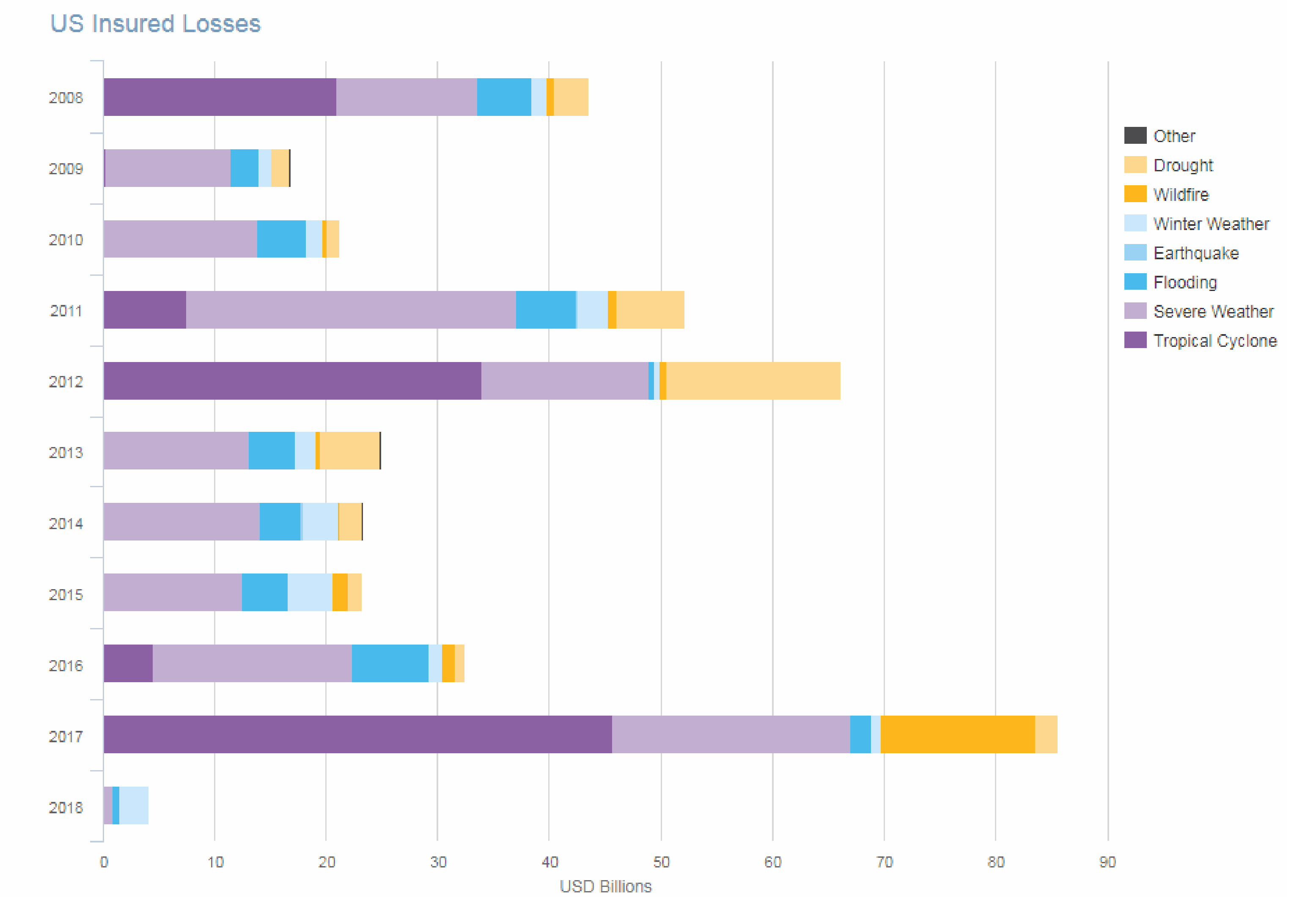
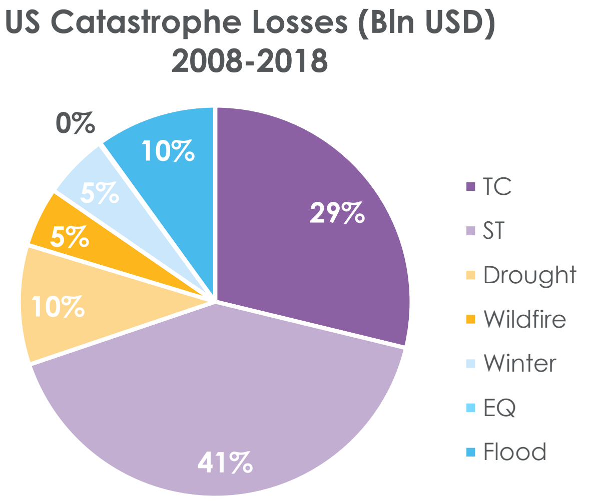
Severe Thunderstorms Losses can Rival Those Risks of More "Traditional" Concerns…



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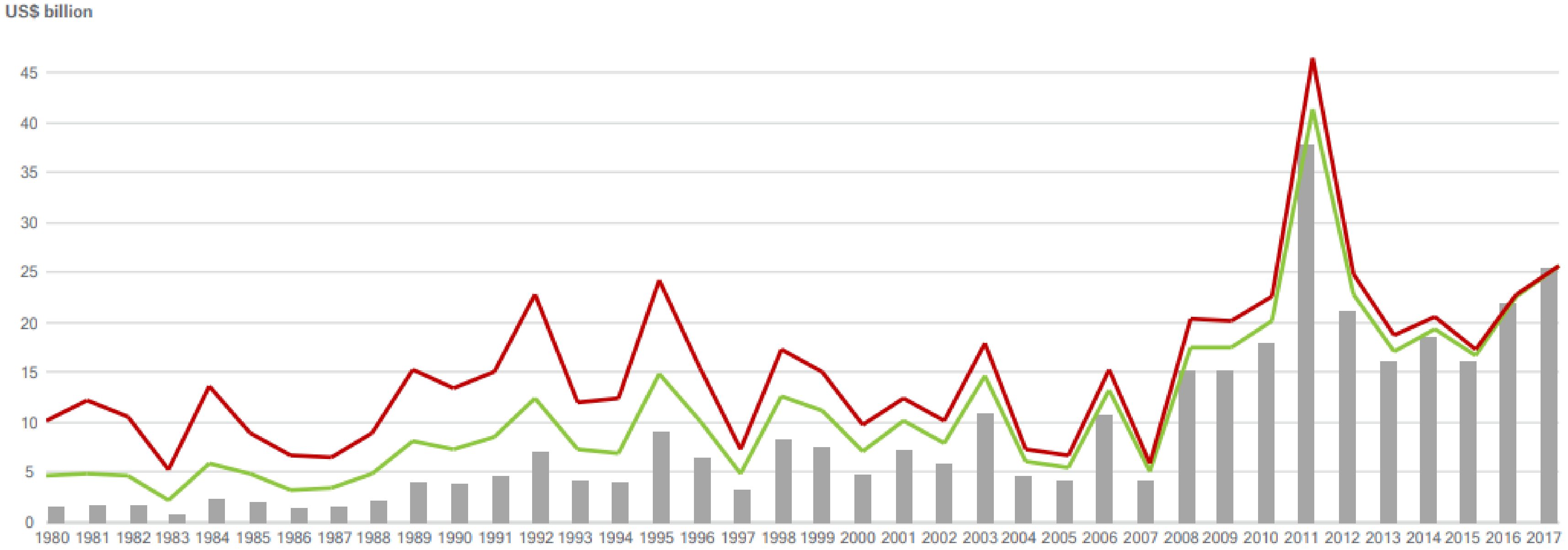
… And these Losses have Been Steadily Increasing Over the Last 30 Years

NatCatSERVICE

Munich RE

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

Relevant convective storm events
in the United States 1980 – 2017



- Nominal overall losses
- Inflation adjusted overall losses (in 2017 values)
- Normalised overall losses (in 2017 values)

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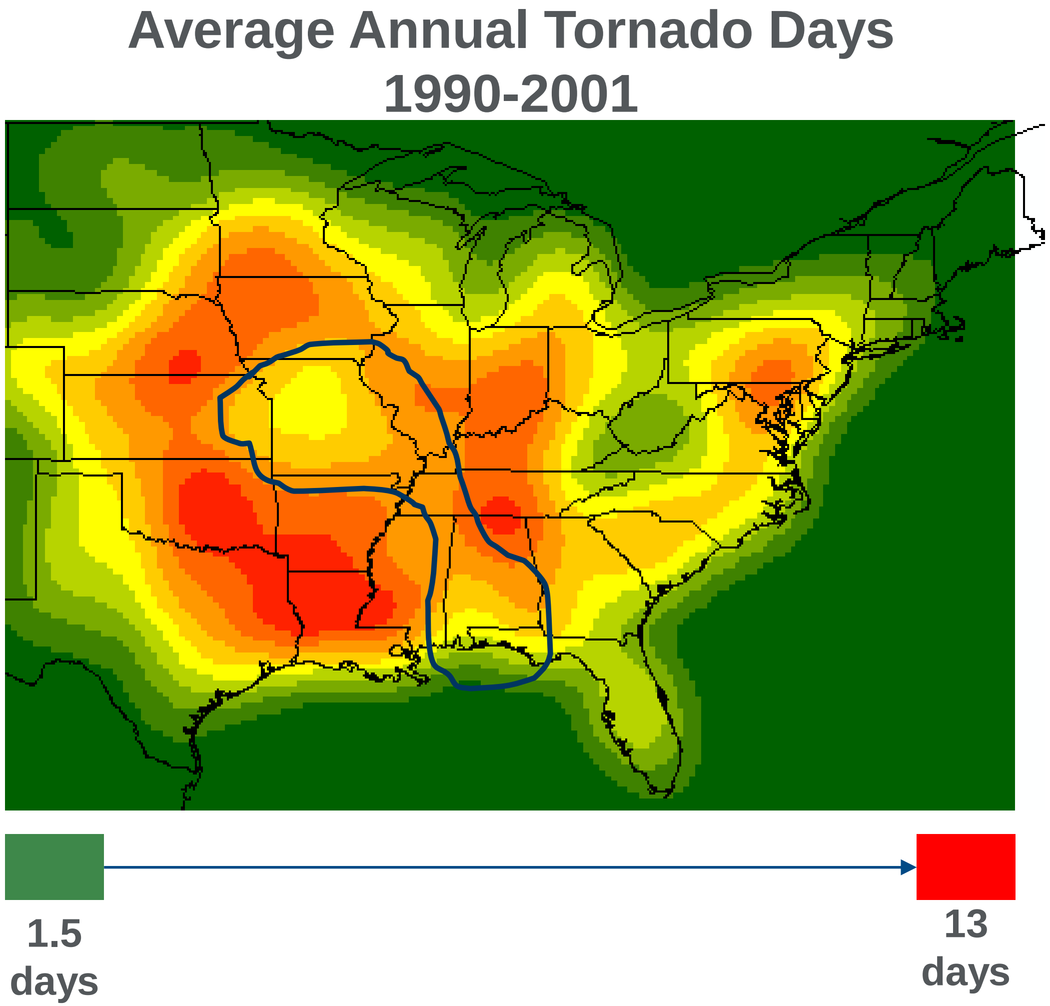
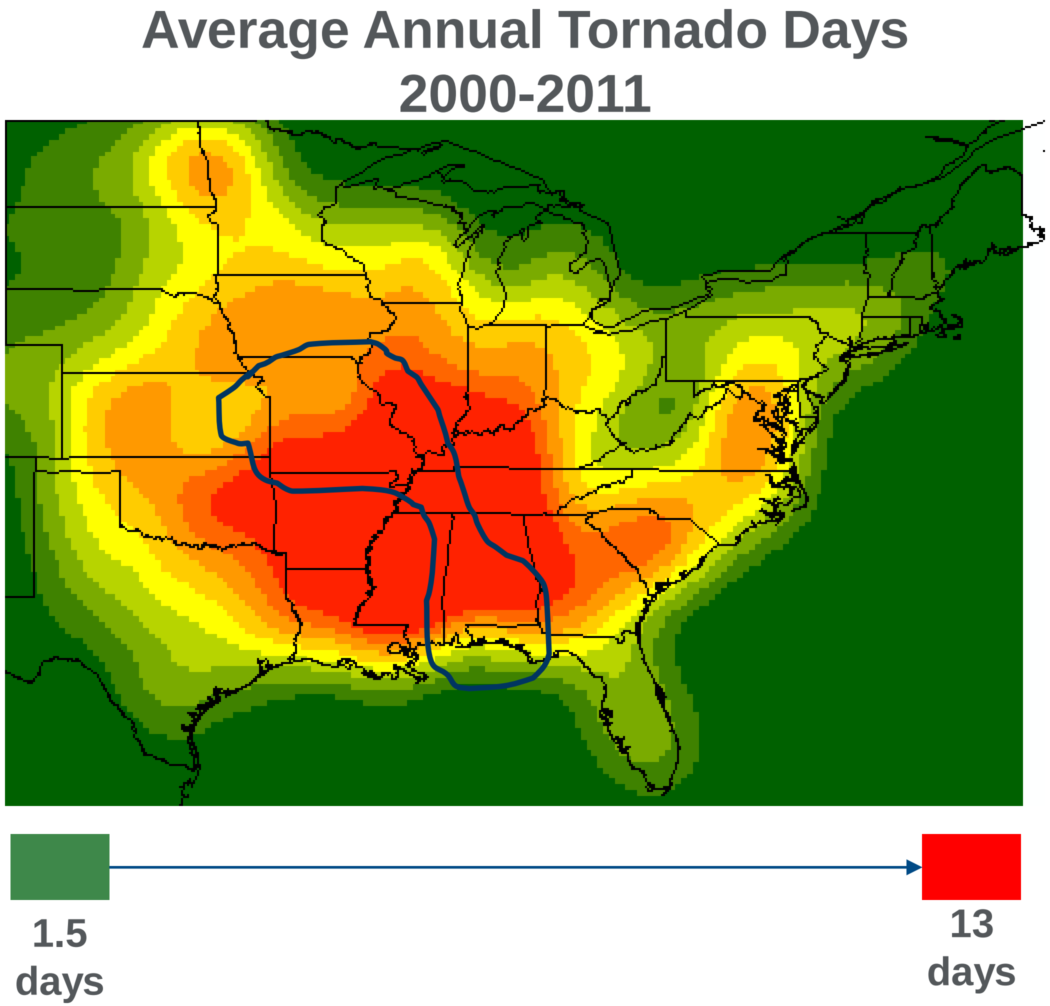
Thunderstorms Also Exhibit High Degrees of Year-to-Year Variability…





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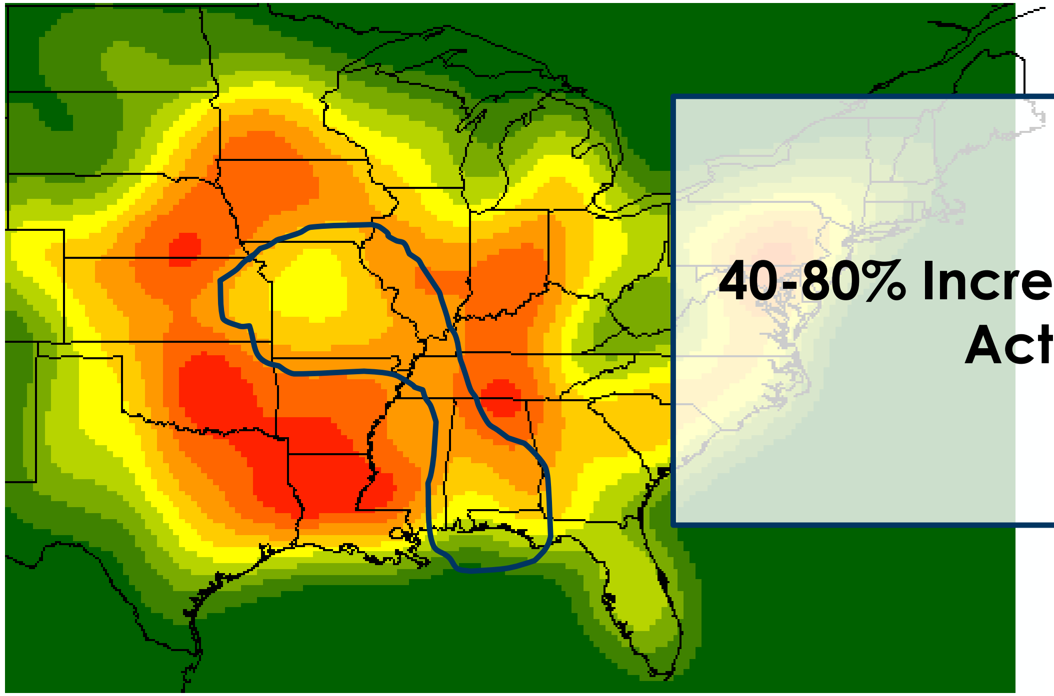
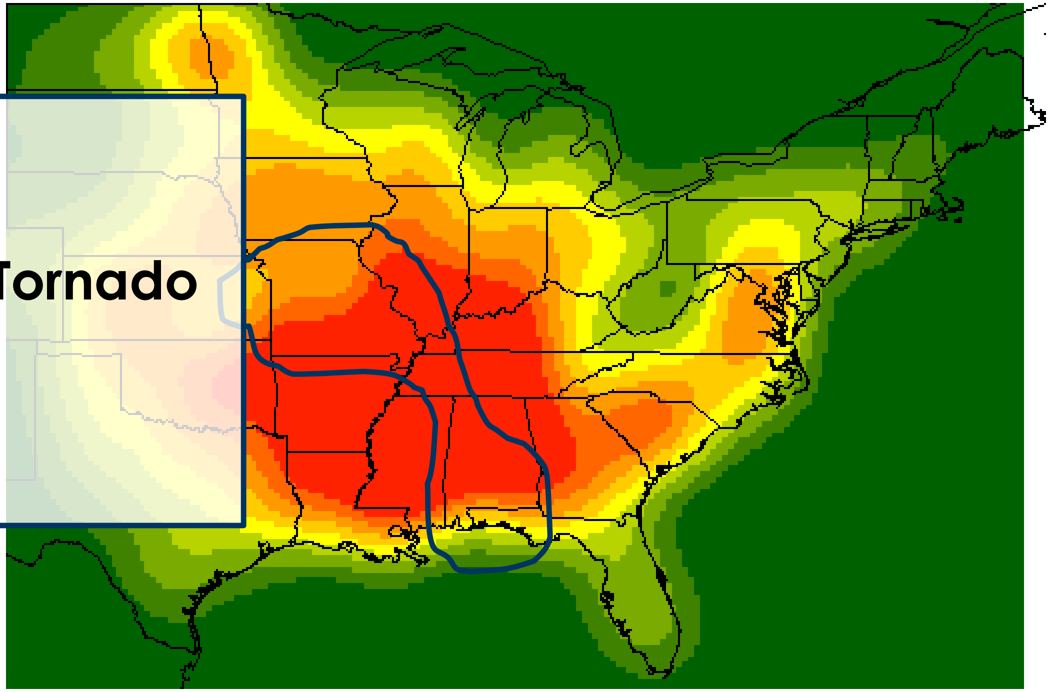
Thunderstorms Also Exhibit High Degrees of Year-to-Year Variability…

Average Annual Tornado Days 1990-2001



1.5 days → 13 days

Average Annual Tornado Days 2000-2011



1.5 days → 13 days

40-80% Increase in Tornado Activity!!

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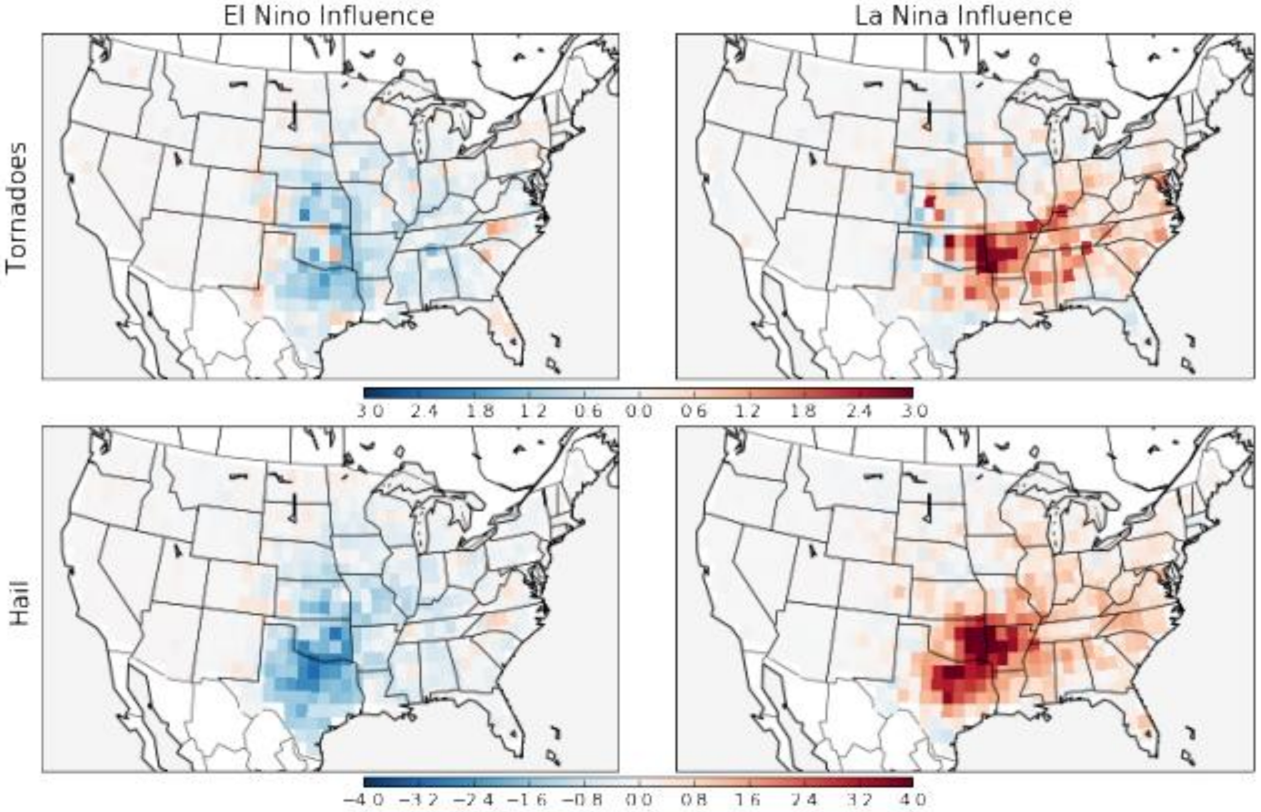
… That is Potentially Affected by Changing/Cyclical Climate Conditions

Prasad Gunturi
EVP - Willis Re

ENSO's Effect on Severe Thunderstorm Activity



But it's more than just ENSO!!

Pacific Decadal Oscillation (PDO)

North Atlantic Oscillation (NAO)

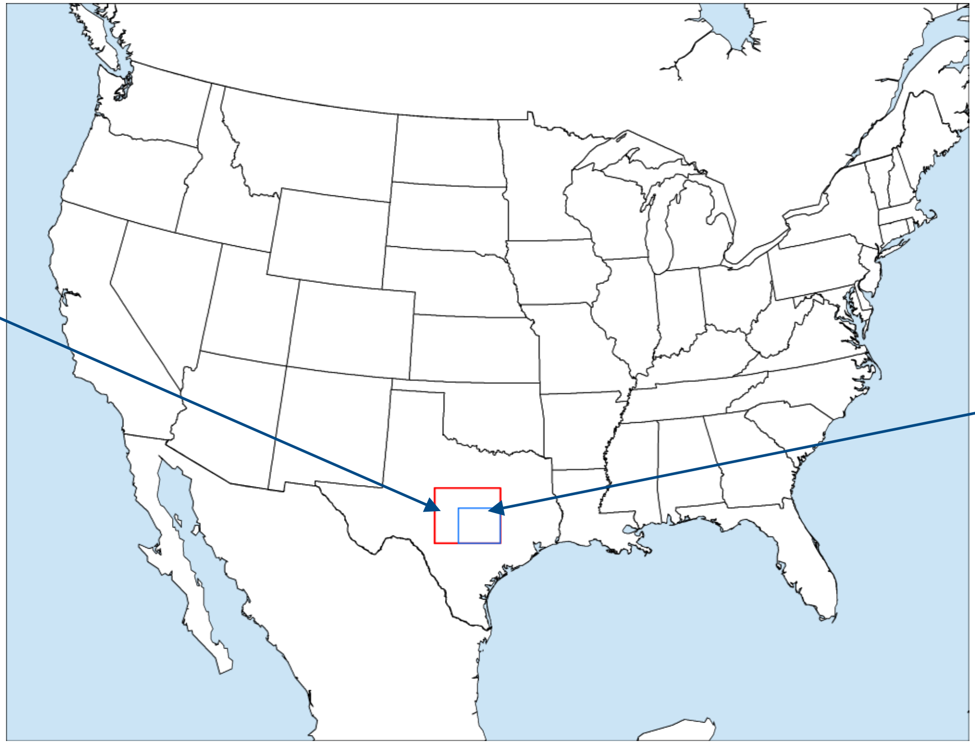
Pacific-North American Pattern (PNA)

Atlantic Multi-Decadal Oscillation (AMO)

…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



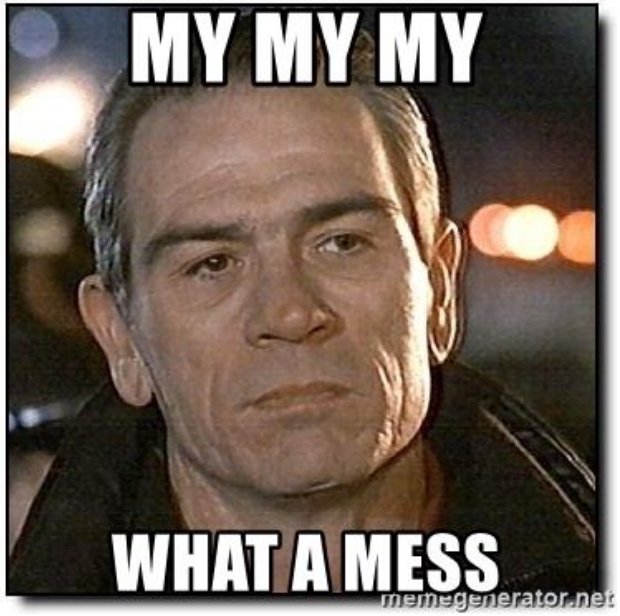
Limiting to the last 20-yrs and EF1+

.5% of Eastern 2/3 of CONUS

So What Do We Have Here???

- 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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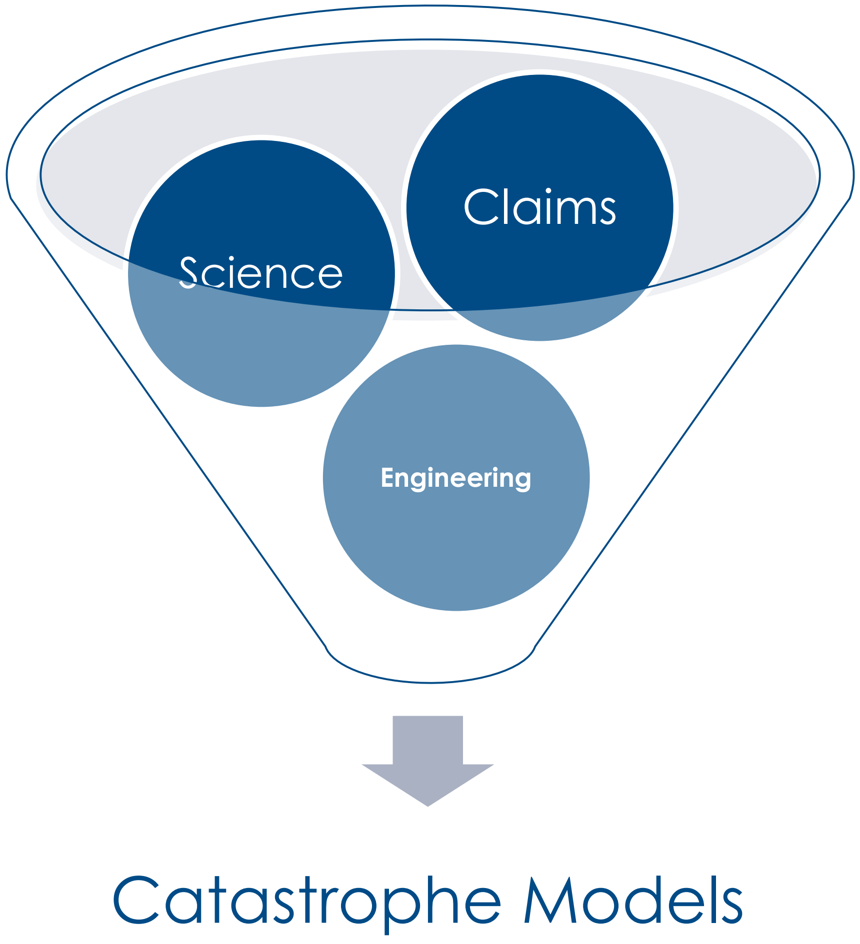
Don’t Worry! The Models Can Help!



- 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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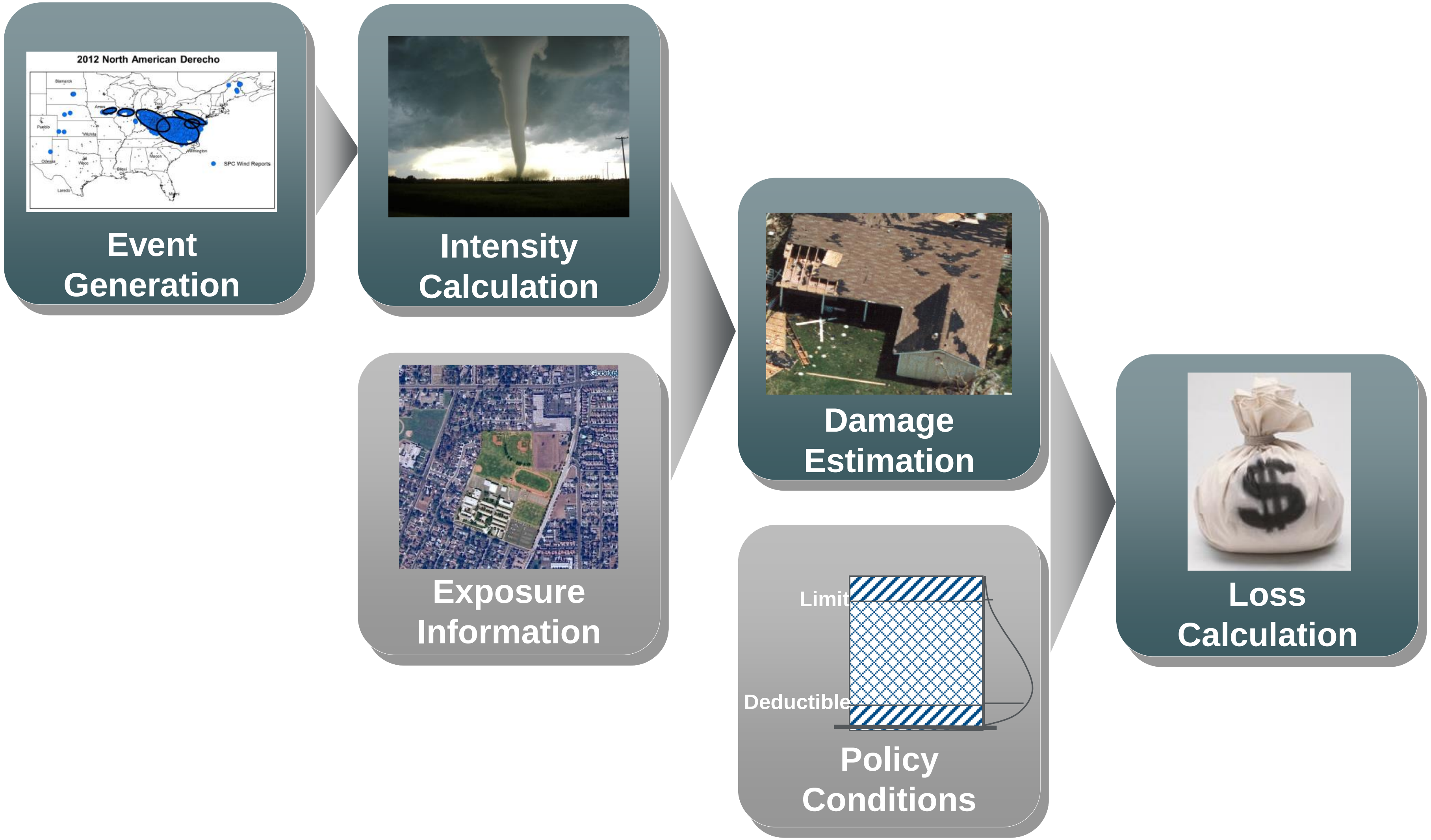
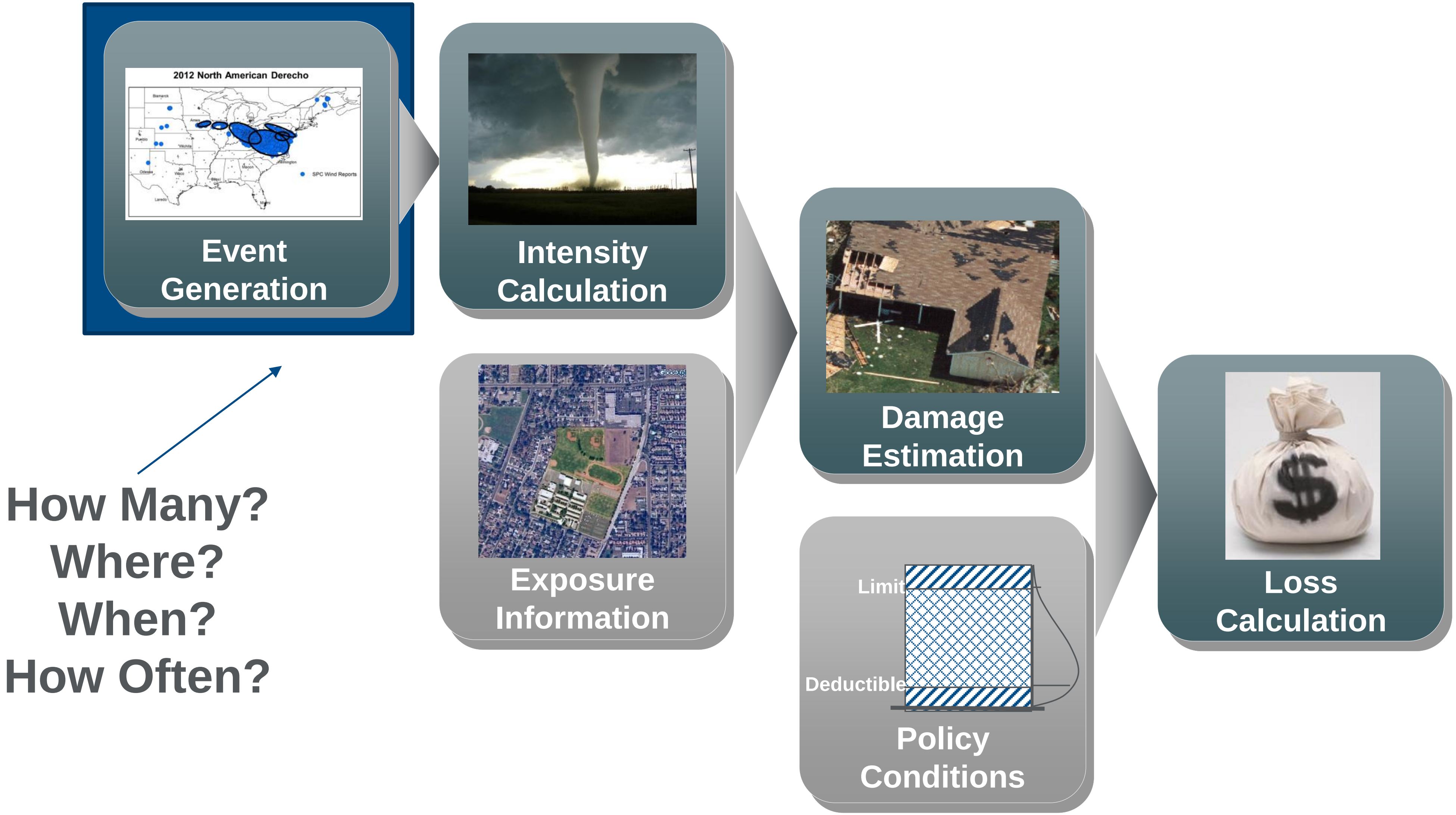
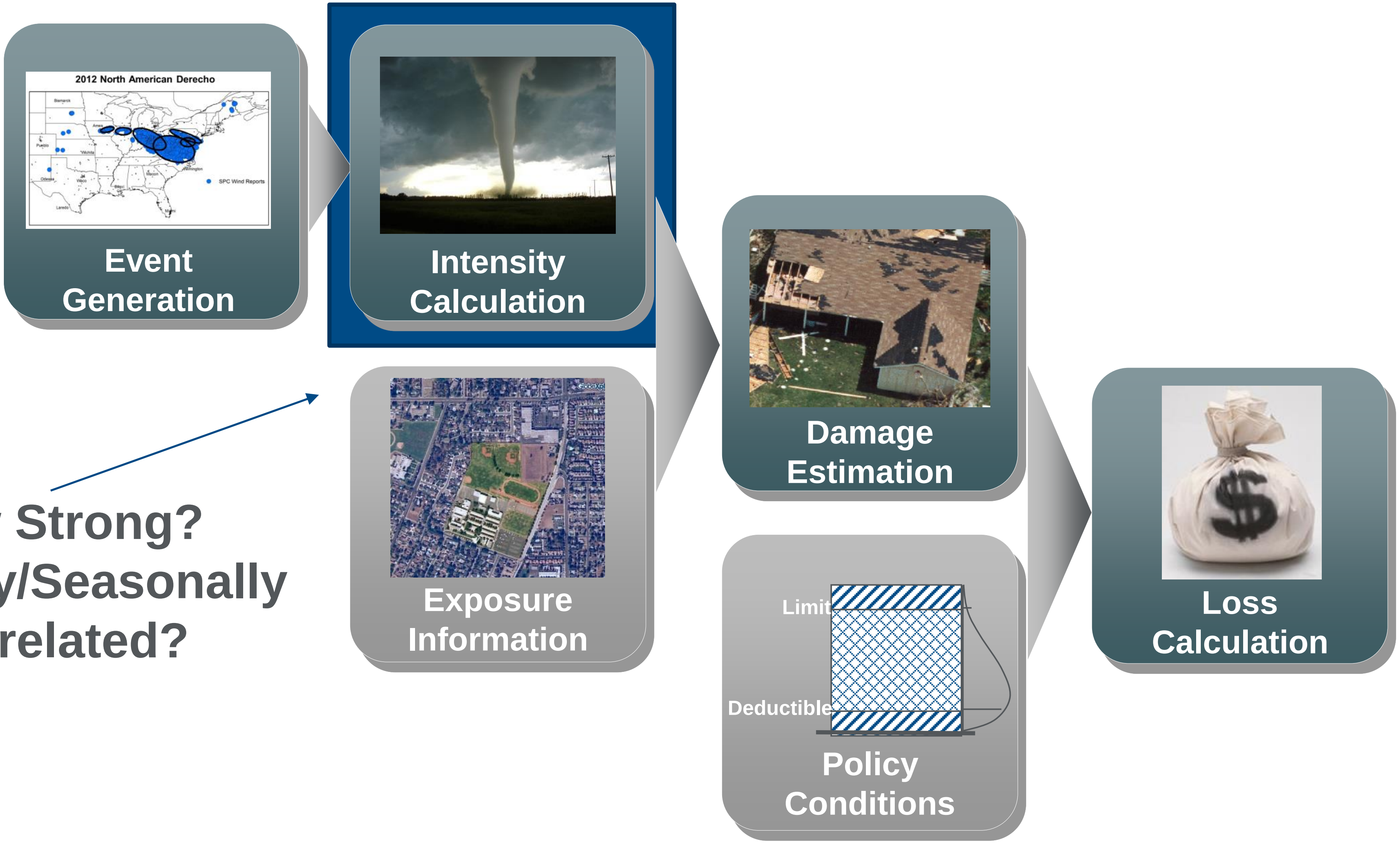
The Basic CAT Modeling Framework



The Basic CAT Modeling Framework

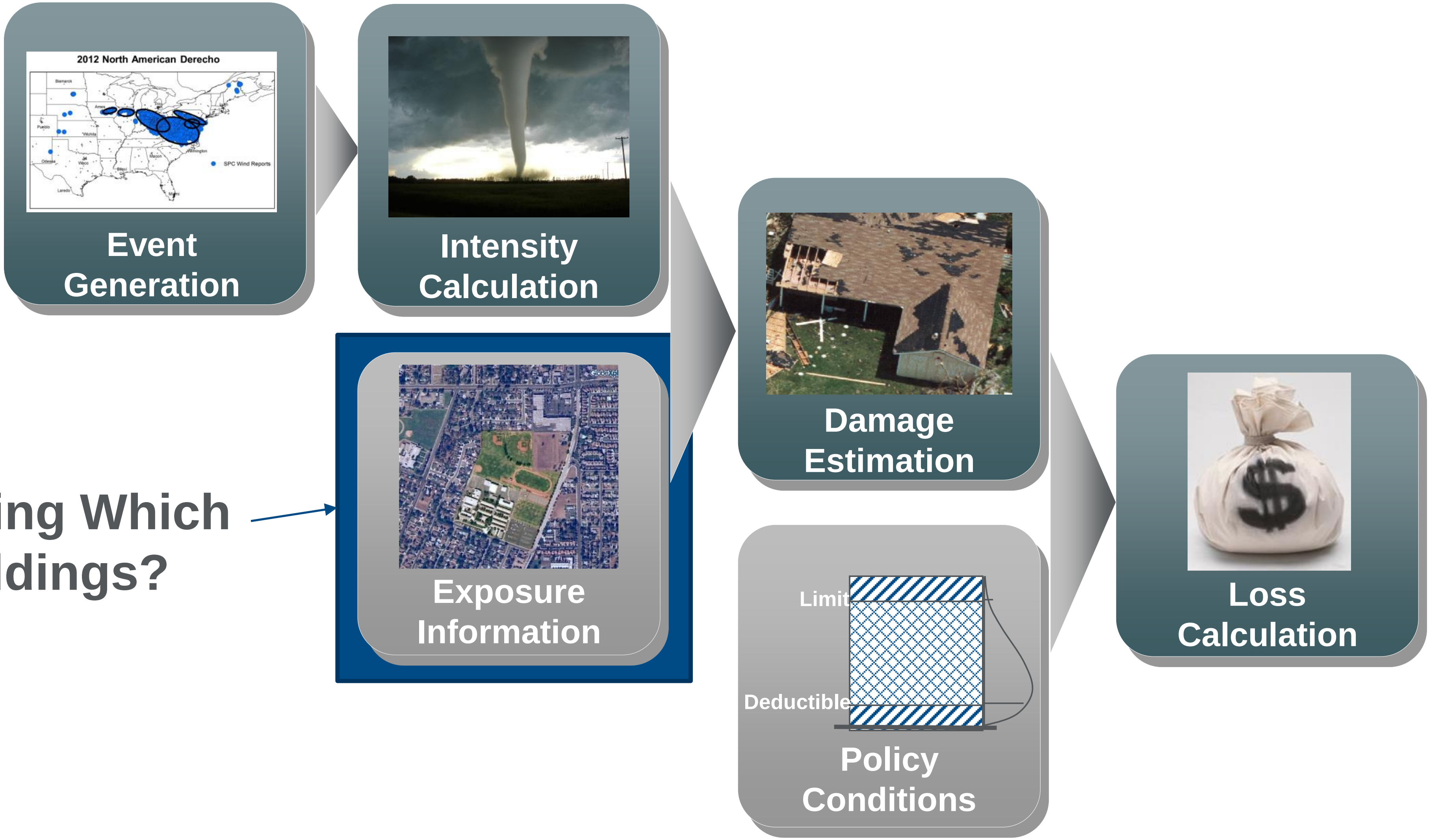


The Basic CAT Modeling Framework



How Strong?
Spatially/Seasonally Correlated?

The Basic CAT Modeling Framework



Affecting Which Buildings?

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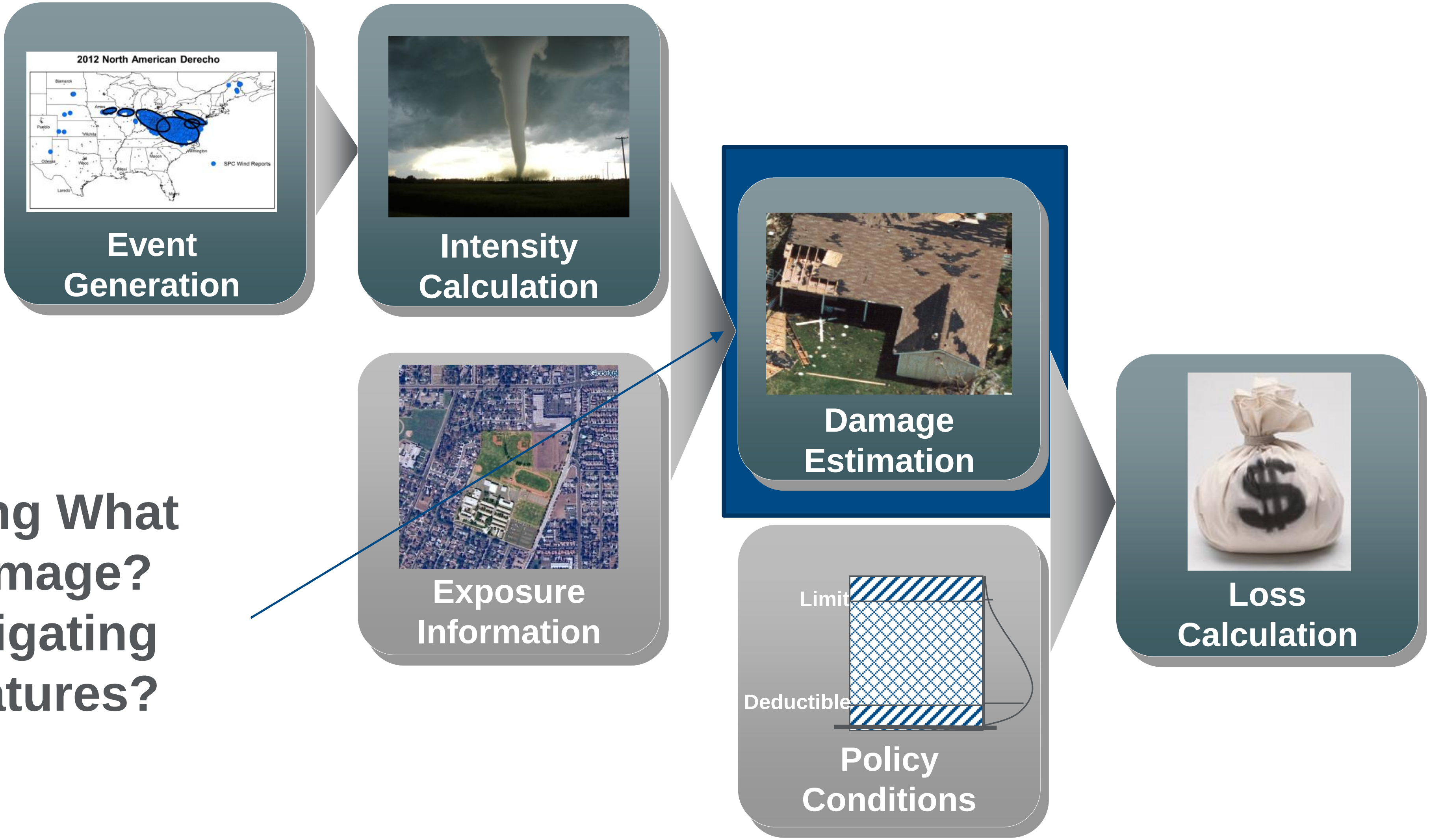
The Basic CAT Modeling Framework



Doing What Damage? Mitigating Features?

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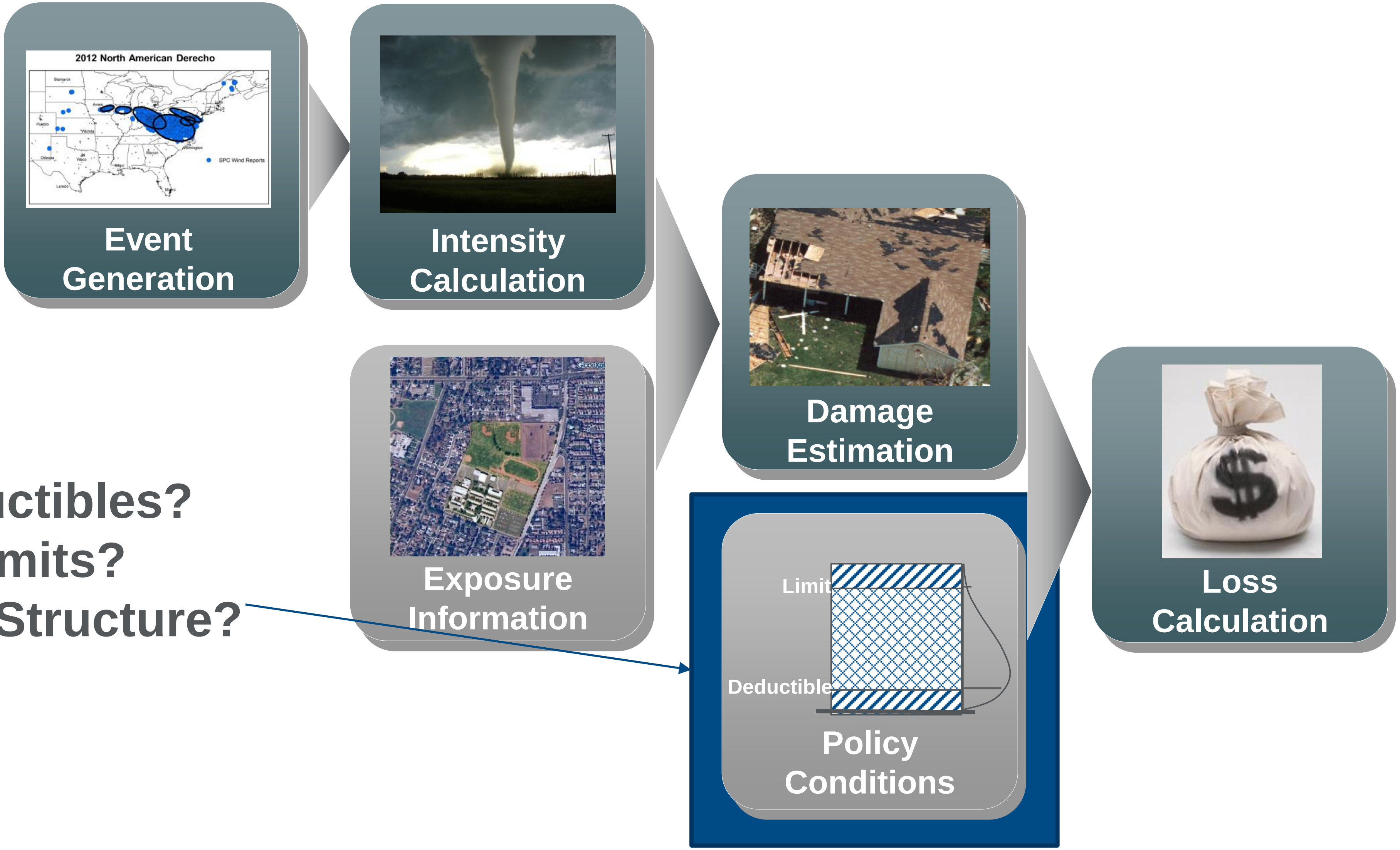
The Basic CAT Modeling Framework



Deductibles?
Limits?
Treaty Structure?

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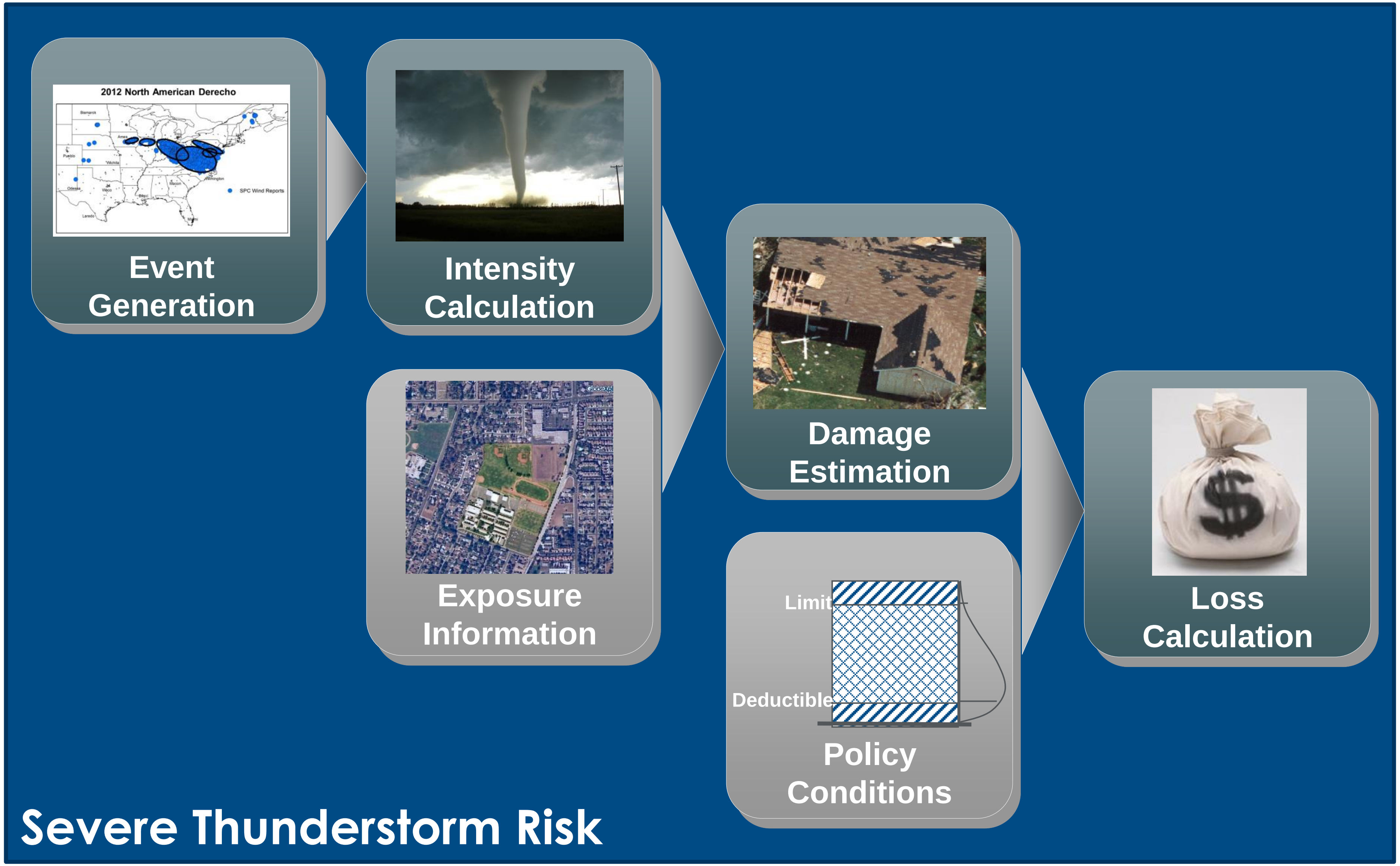
The Basic CAT Modeling Framework



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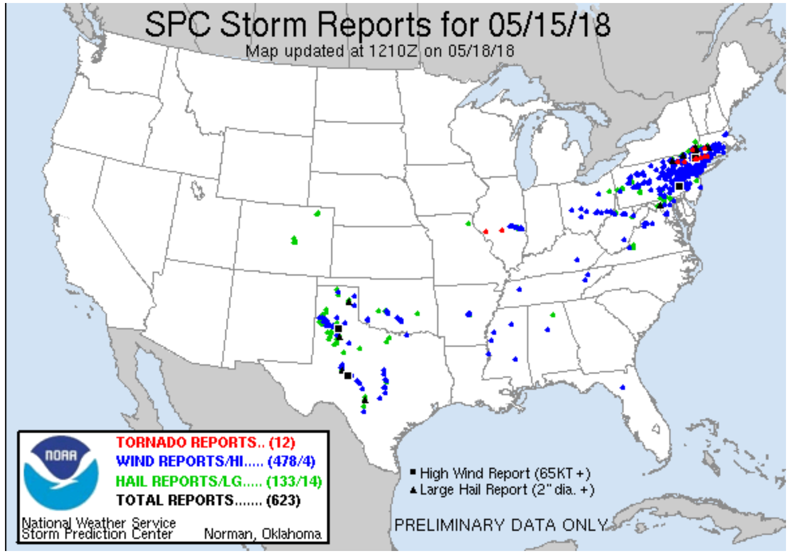
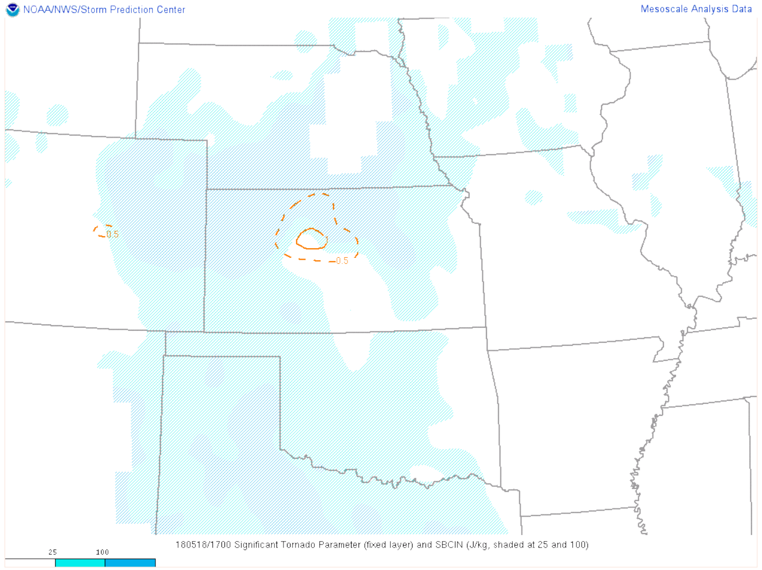
Event Generation: What Data Sources Do We Have to Quantify the Risk?

Eye-witness Reports



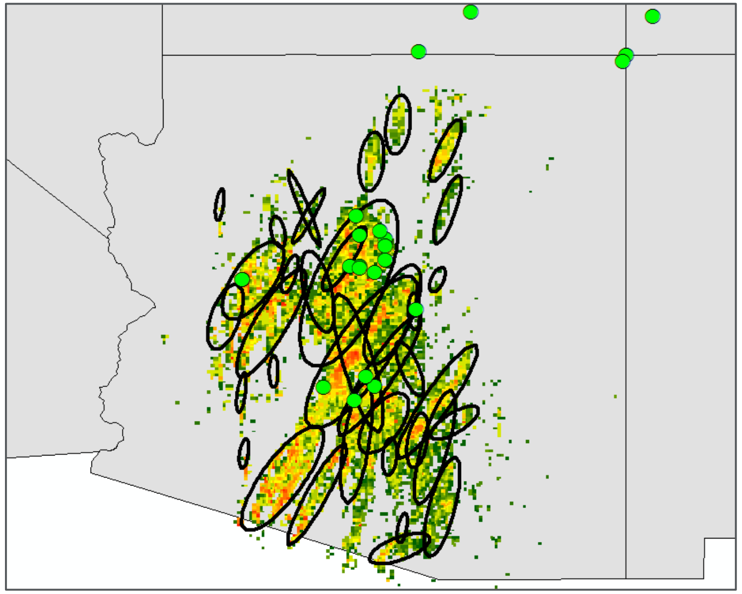
Ground "Truth" But Biased by Population Changes

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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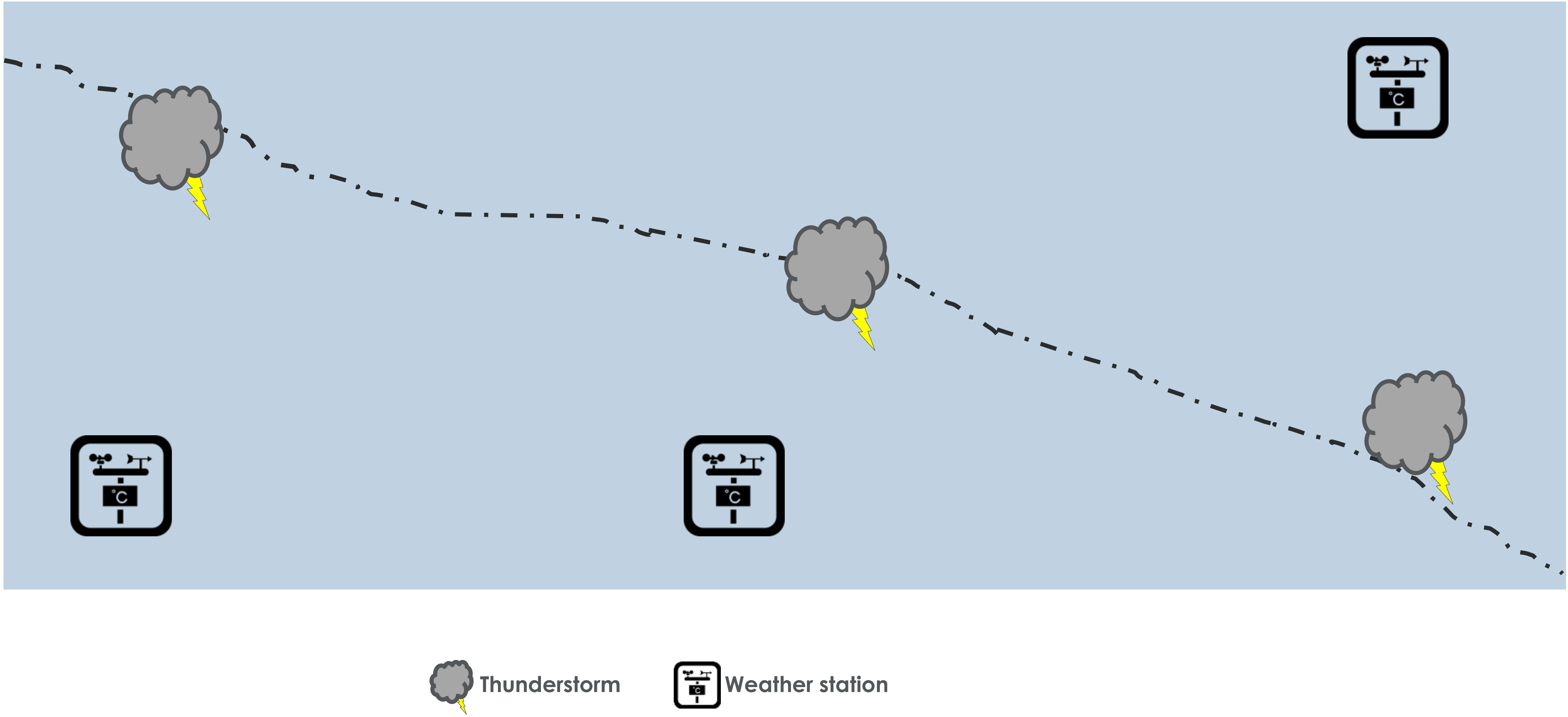
Scale of Storms Makes Them Difficult to Observe



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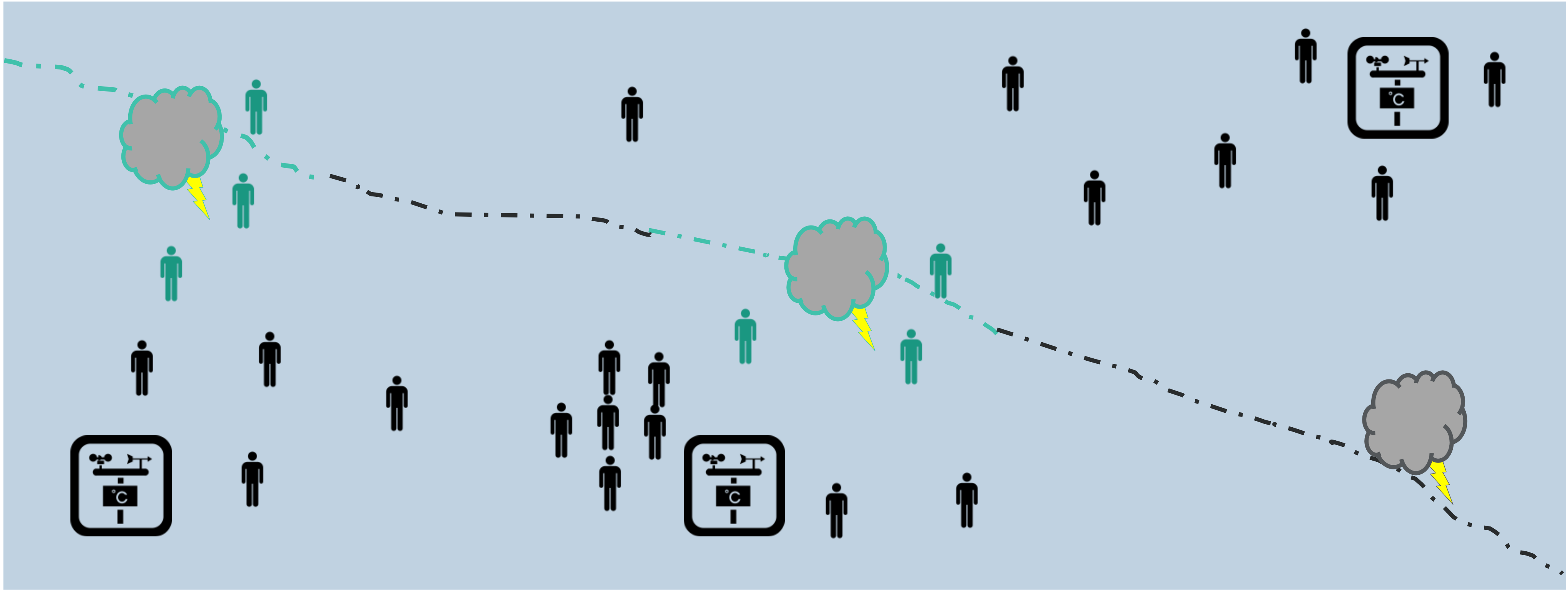
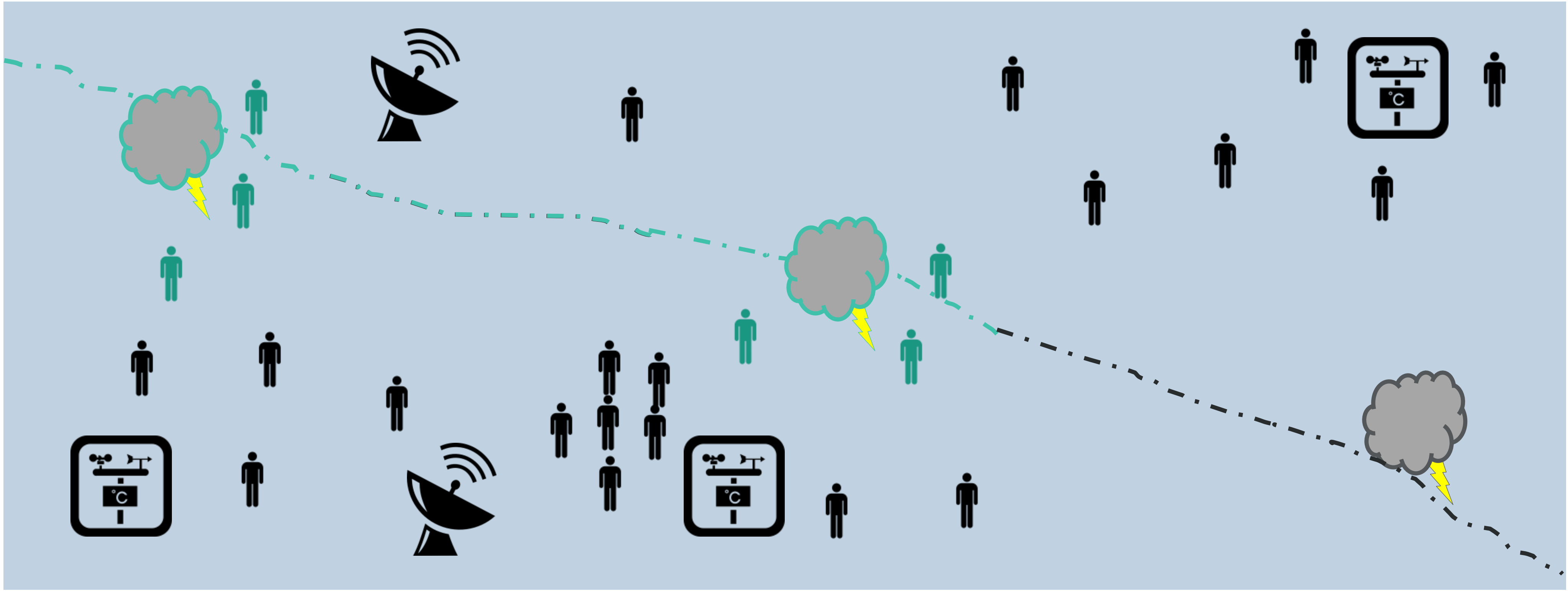


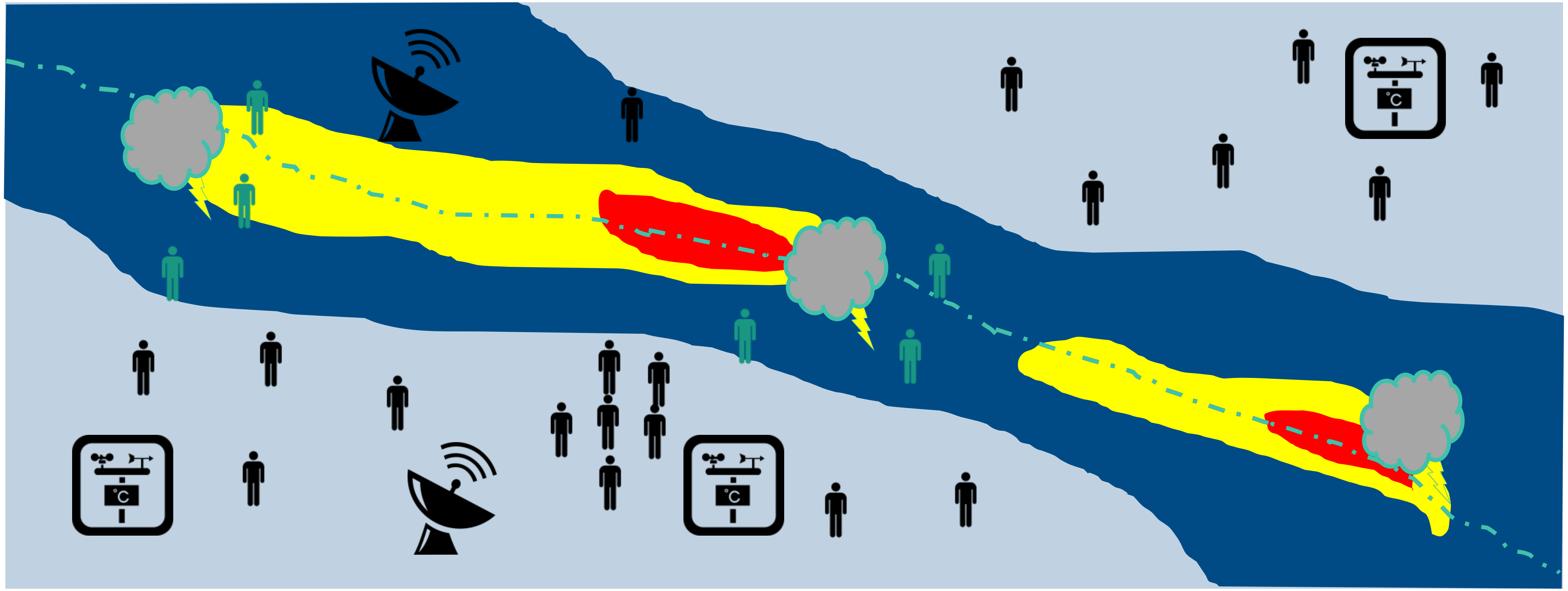
Thunderstorm Weather station Observer

Scale of Storms Makes Them Difficult to Observe

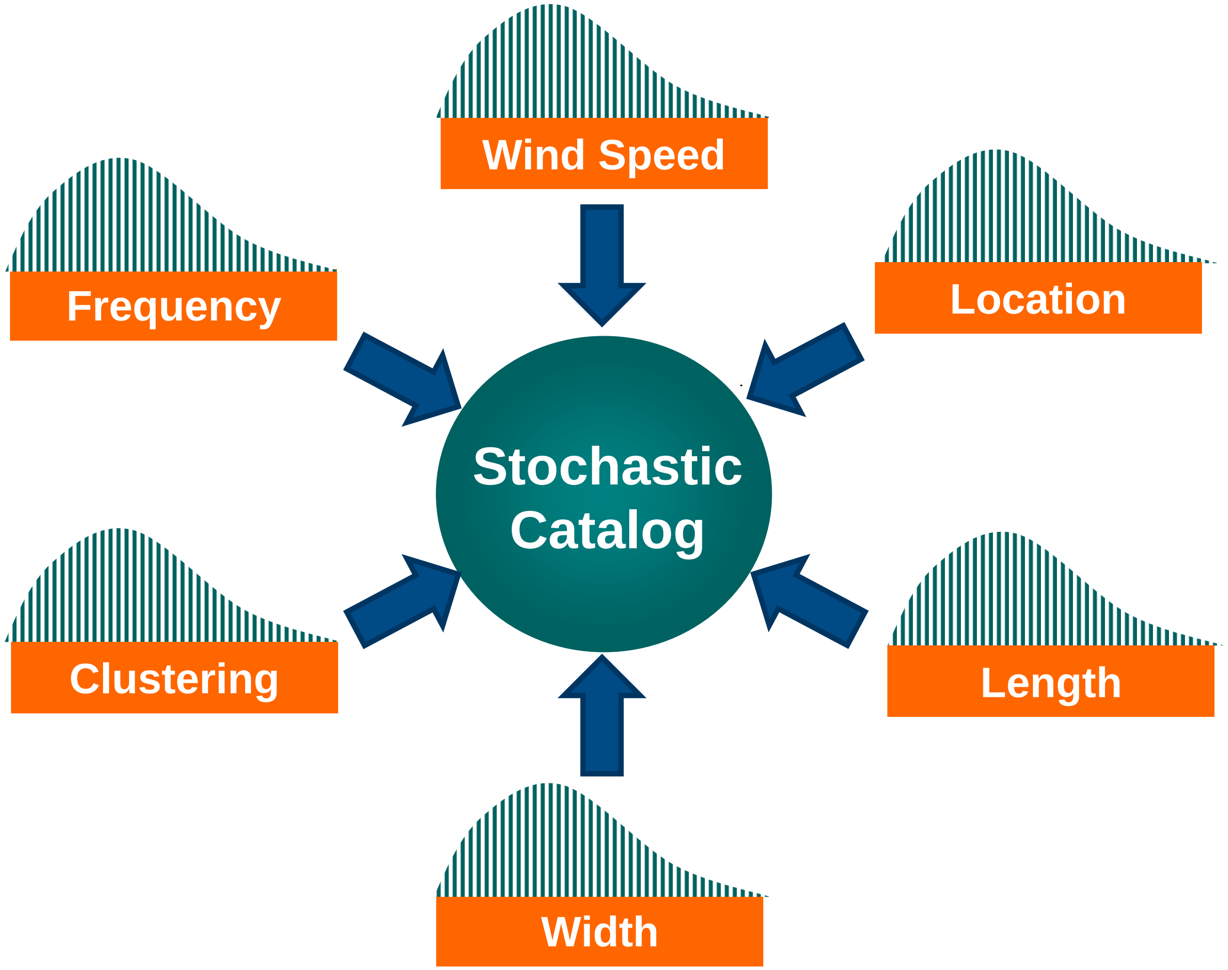


Radar Thunderstorm Weather station Observer

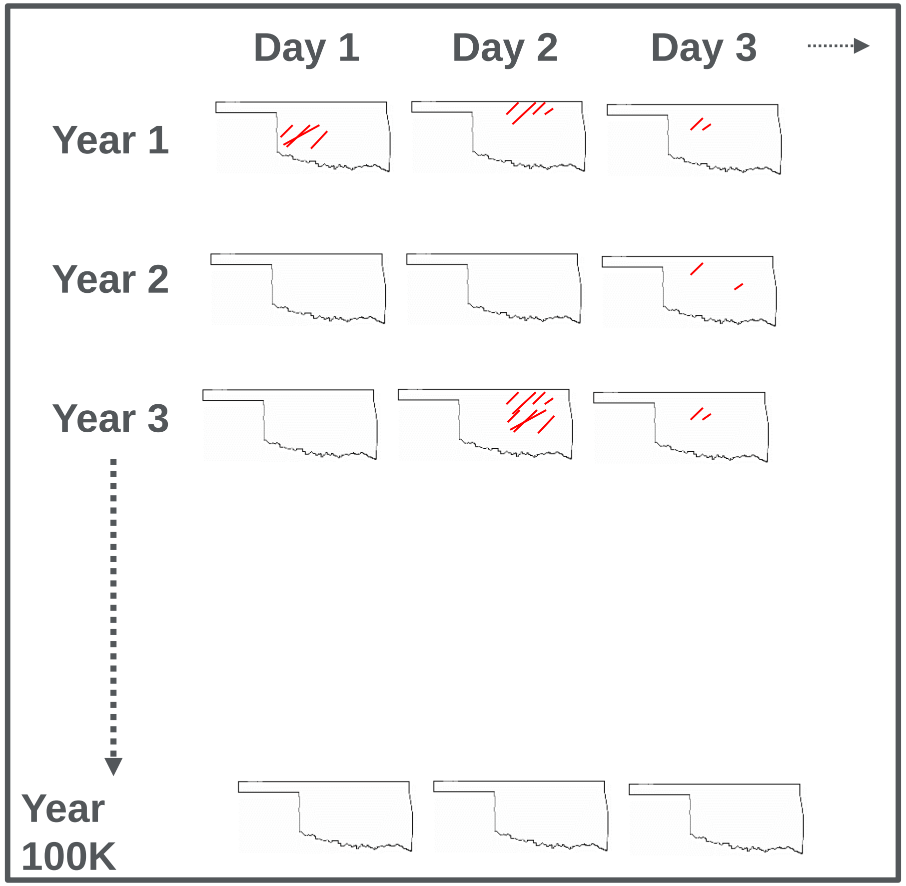
Scale of Storms Makes Them Difficult to Observe



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



A 100K Year Stochastic Catalog

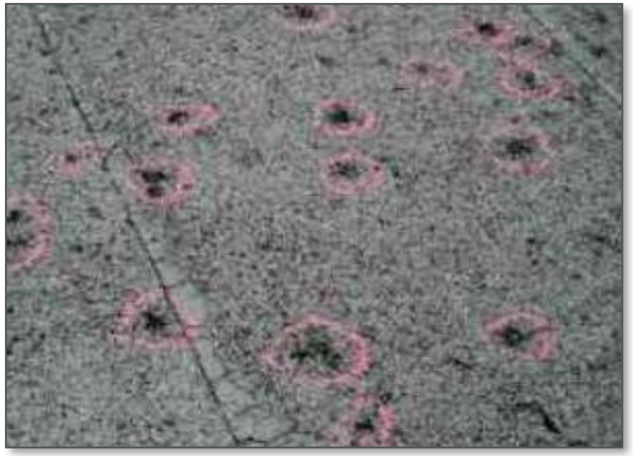


Now that We Have a Catalog… How Do We Calculate Damage?

Experiments

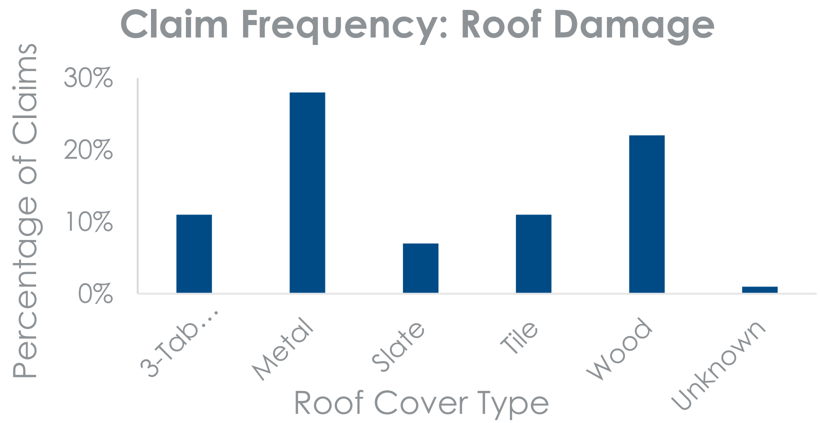
Source: Marshall et al., 2002

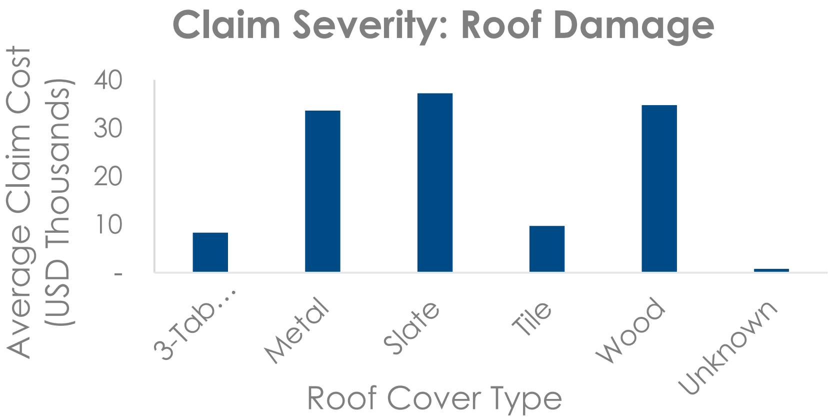
Damage Surveys



Source: RICOWI & AIR Damage Surveys

Claims Studies





Source: IBHS, 2013

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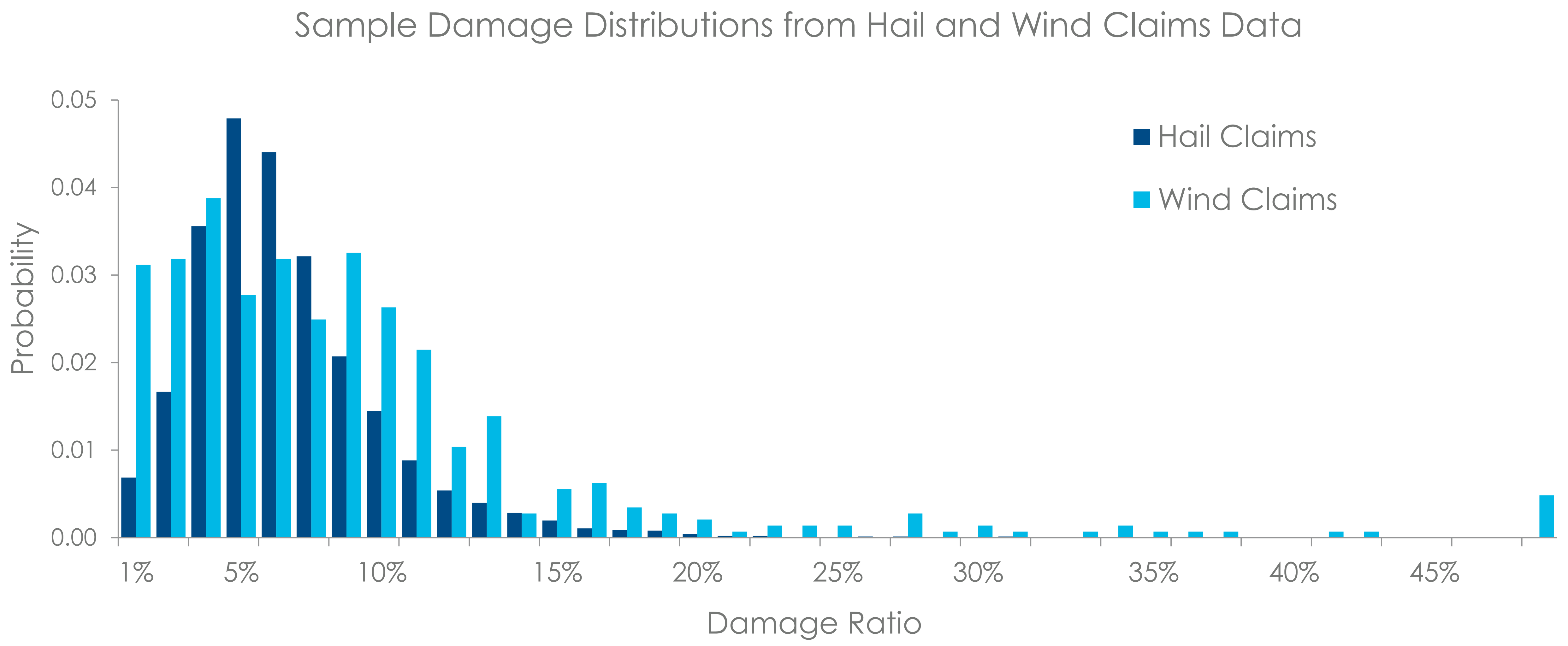
We Can Also Understand Uncertainty Directly Using Claims Data



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

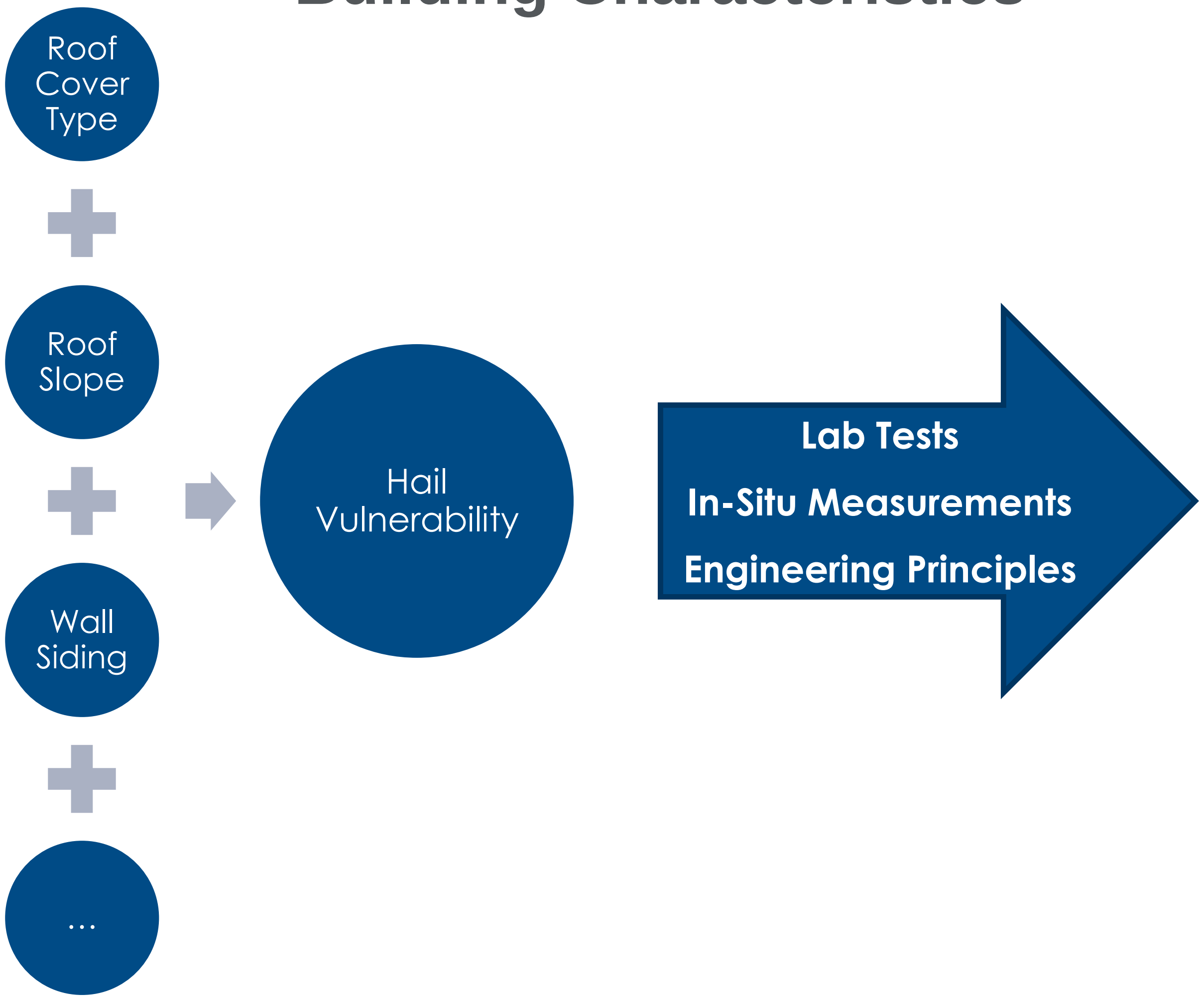
Supported Features in the Severe Thunderstorm Model	
• Seal of Approval	• Roof Anchorage
• Floor of Interest	• Year Roof Built
• Building Condition	• Wall Type
• Tree Exposure	• Wall Siding
• Small Debris Source	• Glass Type
• Large Missile Source	• Glass Percent
• Terrain Roughness	• Window Protection
• 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

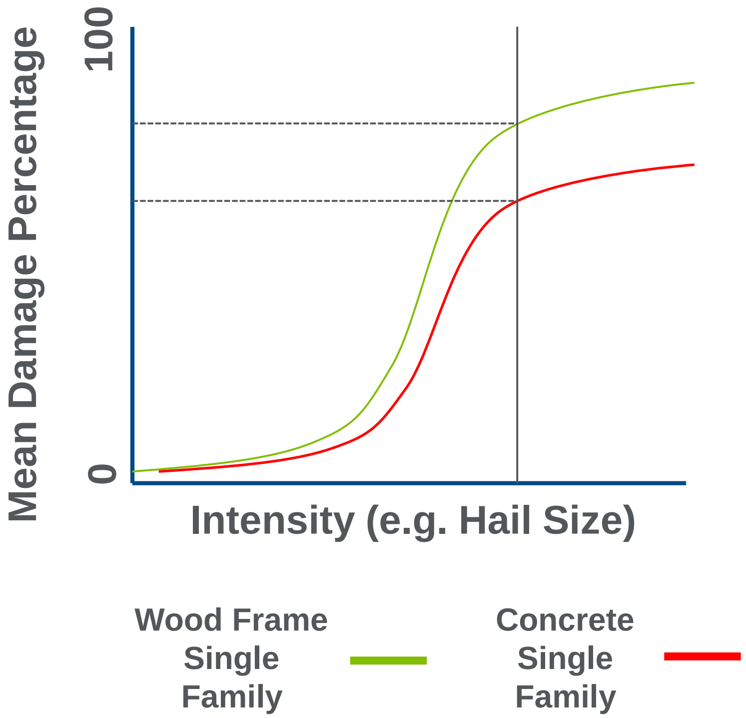
Note: Secondary features highlighted in green are supported for the hail sub-peril.

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

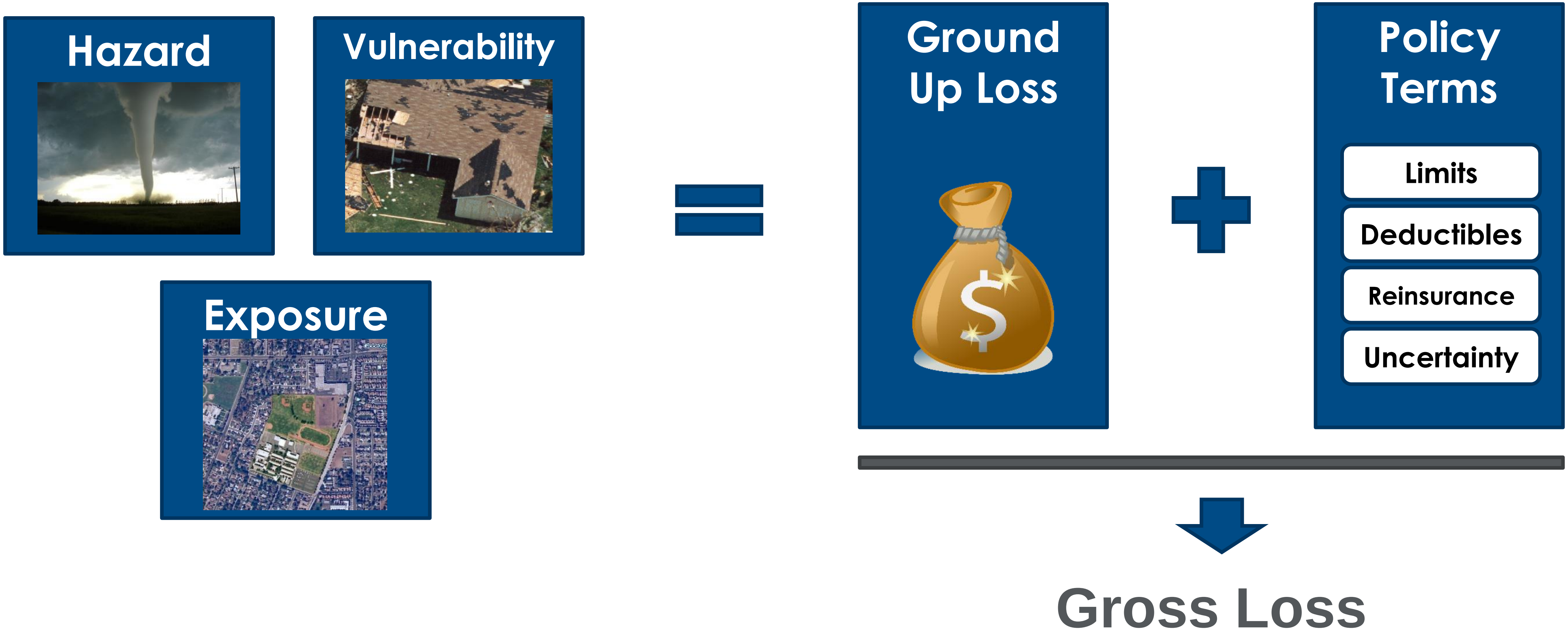
Building Characteristics



Damage Functions



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

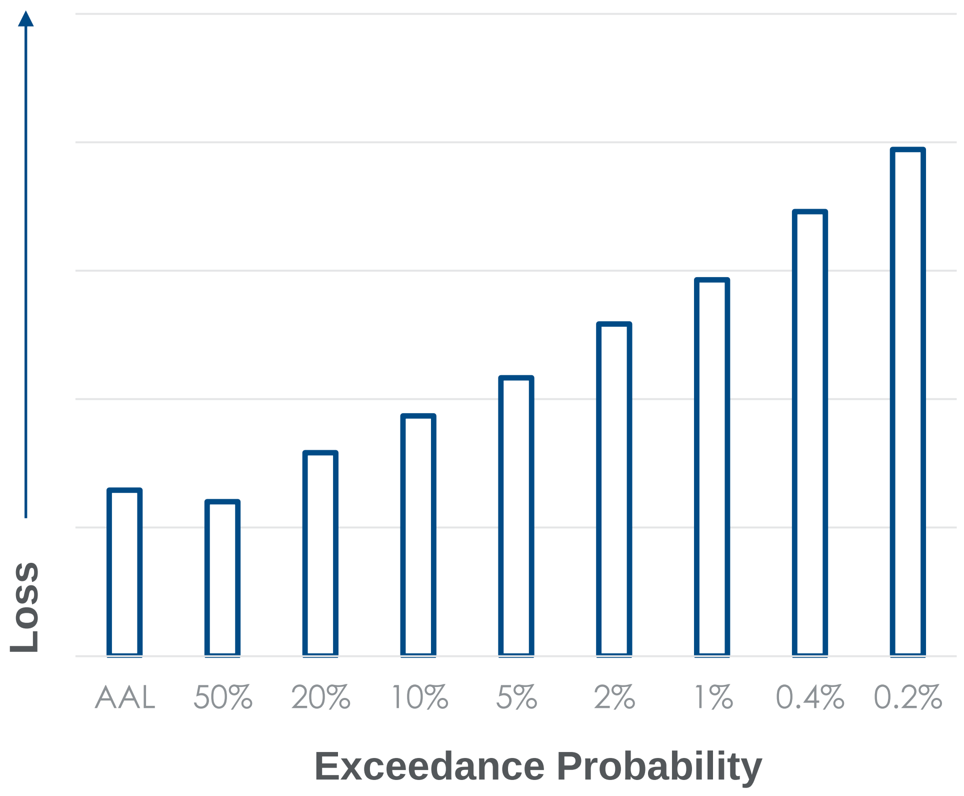
The model also allows us to answer key questions like…

“What do I expect to happen?”

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

Exceedance Probability Curve



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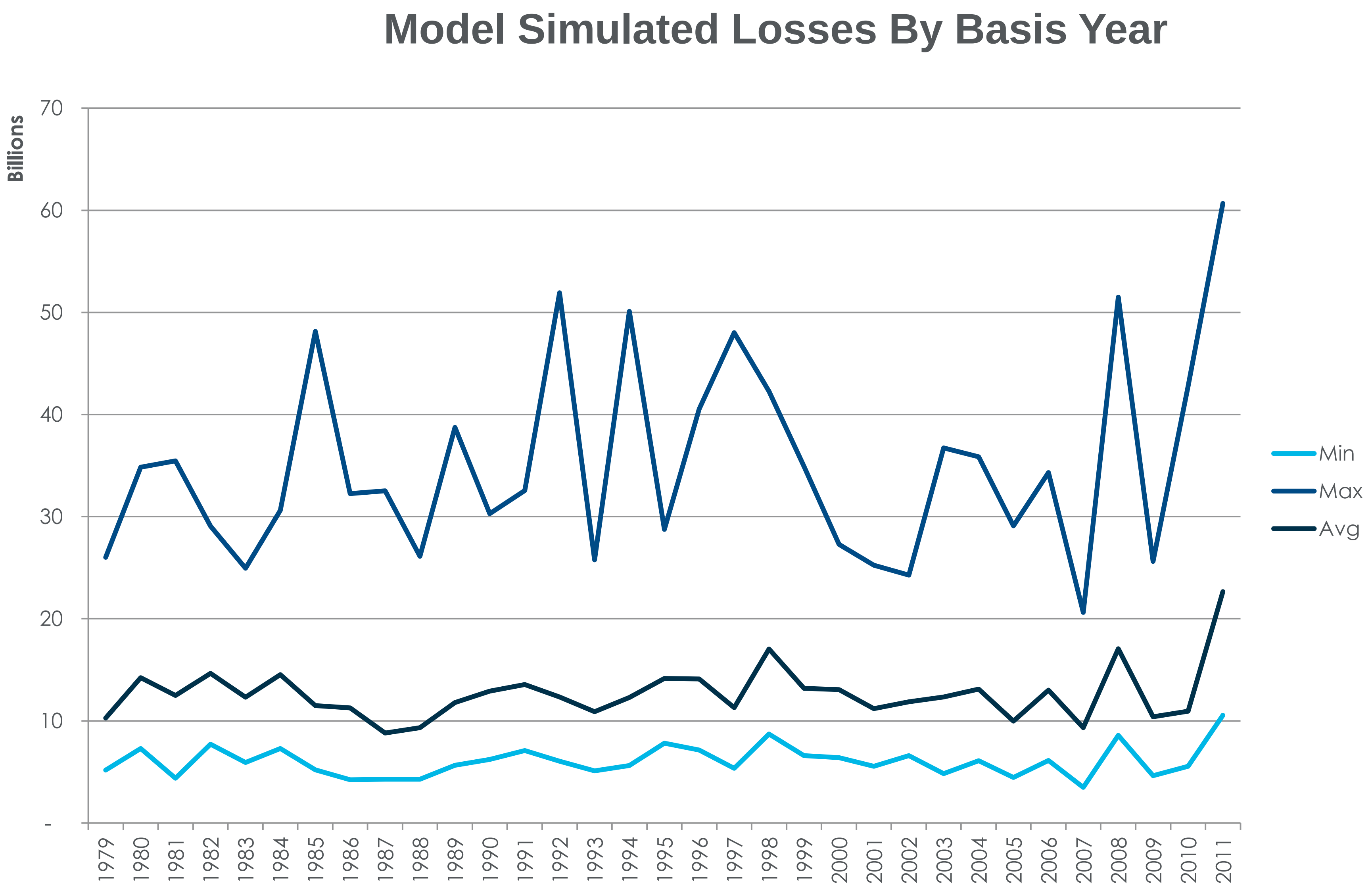
"What could have happened?"



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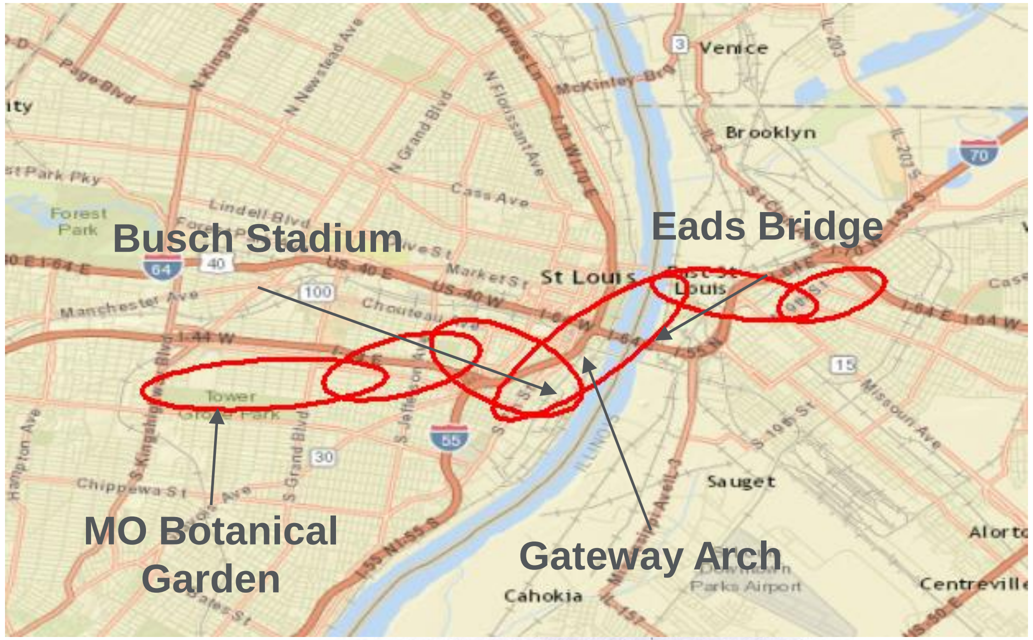
“What if it happened again!?”

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