The Winds of Change

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The Problem: Severe Thunderstorm Losses are GROWING
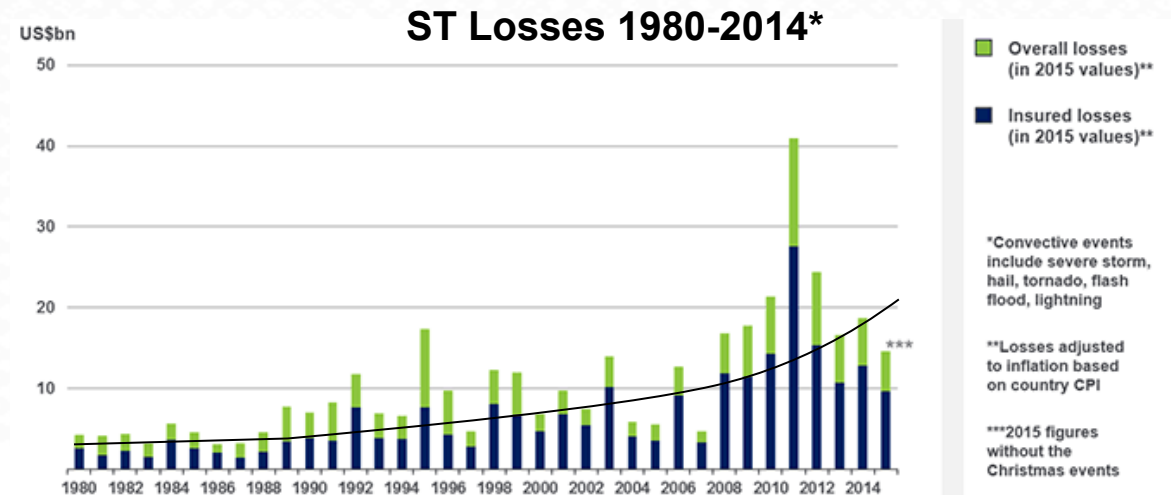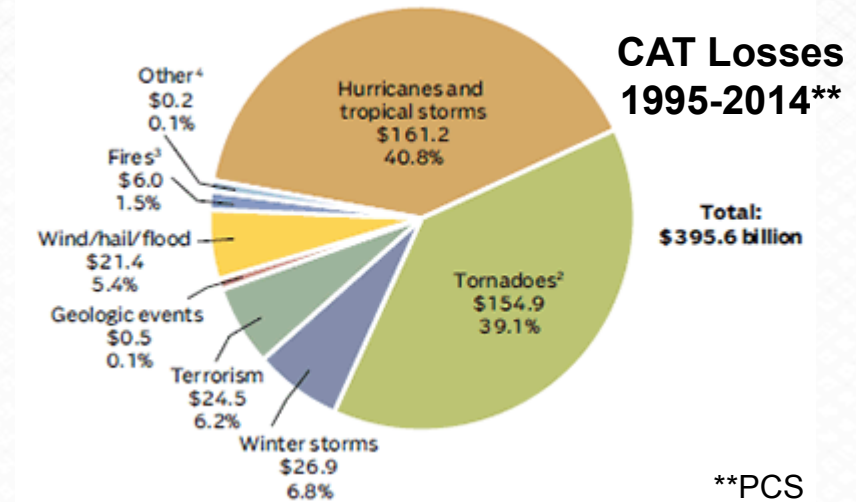
CAT Losses 2015*

As of February 2016	Fatalities	Estimated Overall Losses (US $m)	Estimated Insured Losses (US $m)*
Severe Thunderstorm	114	13,400	9,600
Winter Storms & Cold Waves	98	4,700	3,500
Flood, Flash Flood	86	3,800	1,100
Earthquake & Geophysical	-	Minor l0sses	Minor losses
Tropical Cyclone	5	100	60
Wildfire, Heat Waves, & Drought	14	4,400	1,900
Totals	**317**	**26,400**	**16,100**

CAT Losses 2014*

As of January, 2015	Number of Events	Fatalities	Estimated Overall Losses (US $m)	Estimated Insured Losses (US $m)
Severe Thunderstorm	62	98	17,000	12,300
Winter Storm, winter damage, cold wave, snow storm	13	115	3,700	2,300
Flood, flash flood, storm surge	20	5	1,800	500
Earthquake & Geophysical, landslides	11	45	750	150
Tropical Cyclone	2	1	95	Minor market losses
Wildfire, Heat, & Drought	11	2	1,700	Minor market losses
Totals	119	266	25,000	15,300

* Munich Re, NatCatSERVICE, PCS

CAT Losses 1995-2014**

Other[4] $0.2 0.1%
Fires[3] $6.0 1.5%
Wind/hail/flood $21.4 5.4%
Geologic events $0.5 0.1%
Terrorism $24.5 6.2%
Winter storms $26.9 6.8%
Tornadoes[2] $154.9 39.1%
Hurricanes and tropical storms $161.2 40.8%

Total: $395.6 billion

**PCS

ST Losses 1980-2014*

US$bn

Legend:
- Overall losses (in 2015 values)**
- Insured losses (in 2015 values)**

*Convective events include severe storm, hail, tornado, flash flood, lightning

**Losses adjusted to inflation based on country CPI

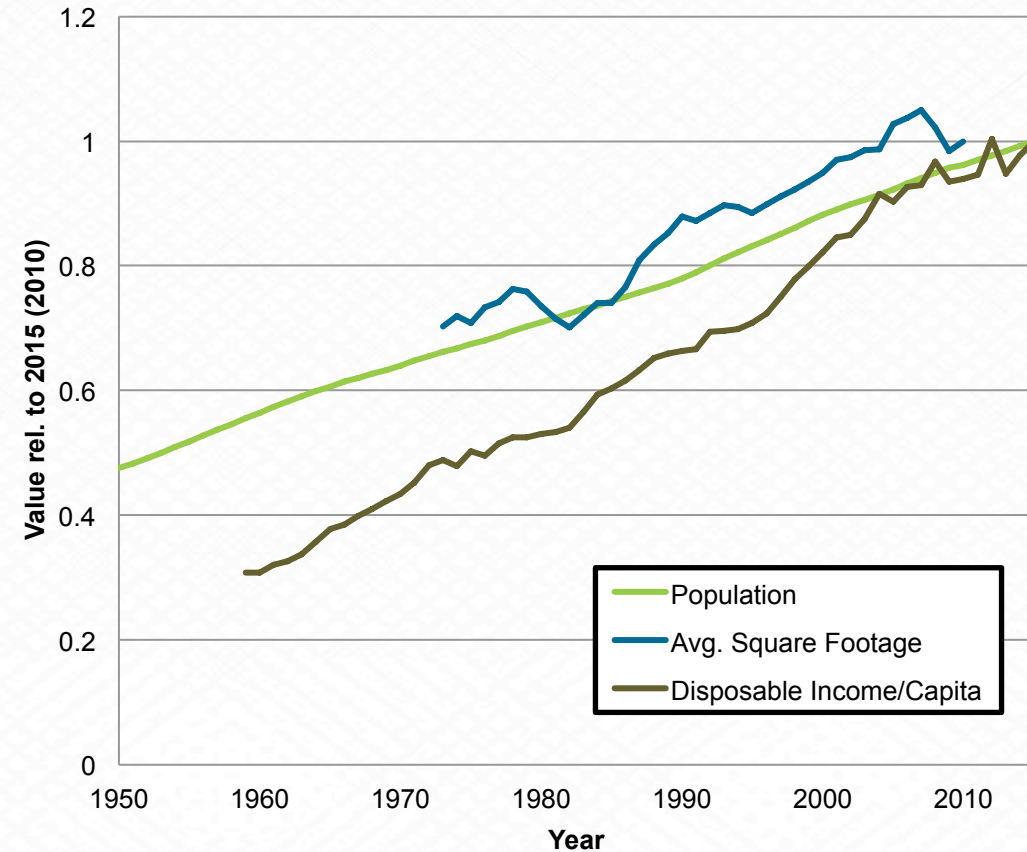***2015 figures without the Christmas events

The Problem: Severe Thunderstorm Losses are GROWING

- More People
- In Bigger Houses
- With More Stuff

Exposure can change SIGNIFICANTLY over a short period of time!!

US Growth Trends

Legend:
- Population
- Avg. Square Footage
- Disposable Income/Capita

Y-axis: Value rel. to 2015 (2010)
X-axis: Year

The Past ≠ The Future

– The changing landscape of tornado risk is a multi-faceted problem

Past	Present	Future

- Population Growth
- Urban Sprawl
- Biased Observations
- Changing Vulnerability

- Data Accuracy
- Hazard Uncertainty
- Model Exclusions

- Climate Change
- Climate Variability
- Exposure Growth

The 2 "Whats" That We Want to Answer…

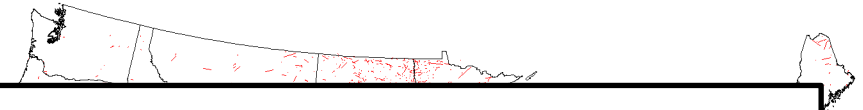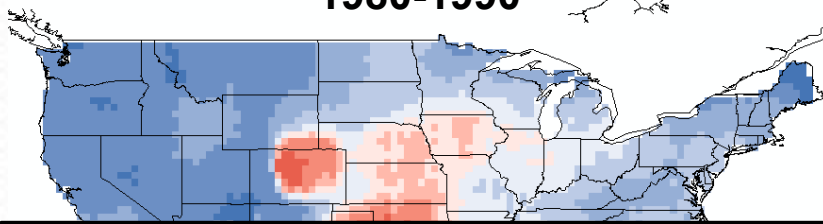
What can the past tell us about tornado loss potential?
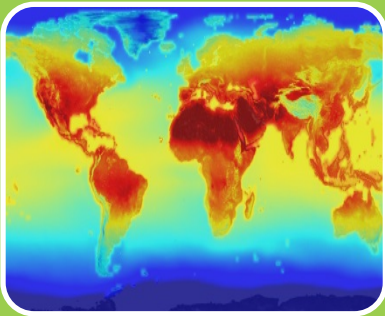
What does the future have in store for us?

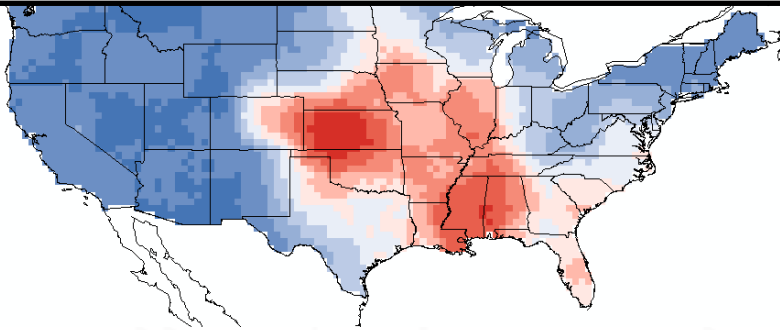# What can the past tell us about tornado loss potential?

- Tornado activity exhibits **significant** decadal variability

- Over the entire observational record, tornadoes have only impacted a small fraction of the country
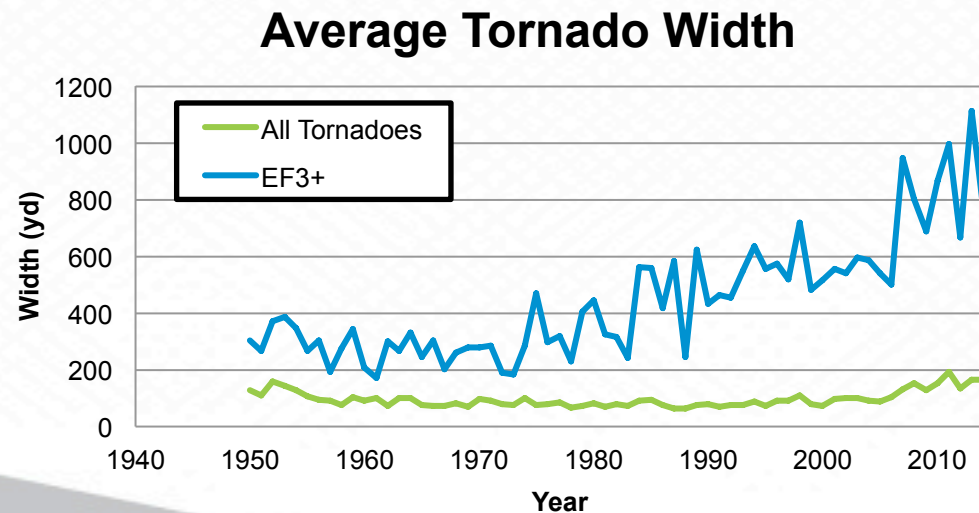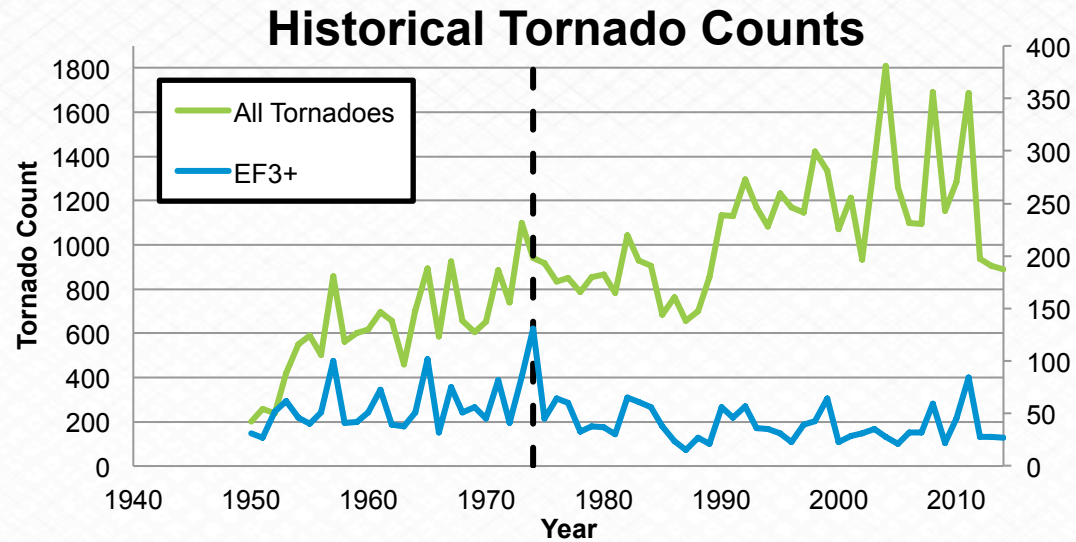
1980-1990

Tornado Occurrence Probability

How many years of data is "enough"?
10? 20? 30? 1000?

1950-2014: Only 8% of CONUS affected
(assuming NO overlap)
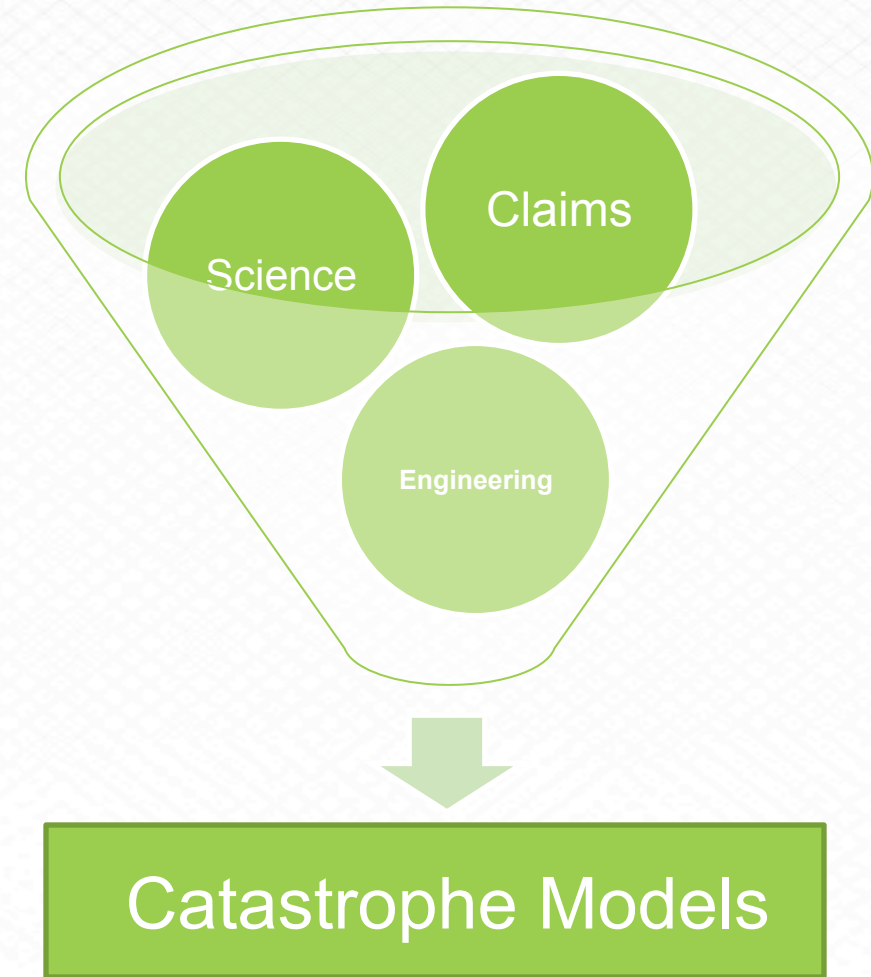
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Even the Data is NOT Without its Own Challenges

Historical Tornado Counts

Average Tornado Width

Data Quality
(and bias)
Matters!!
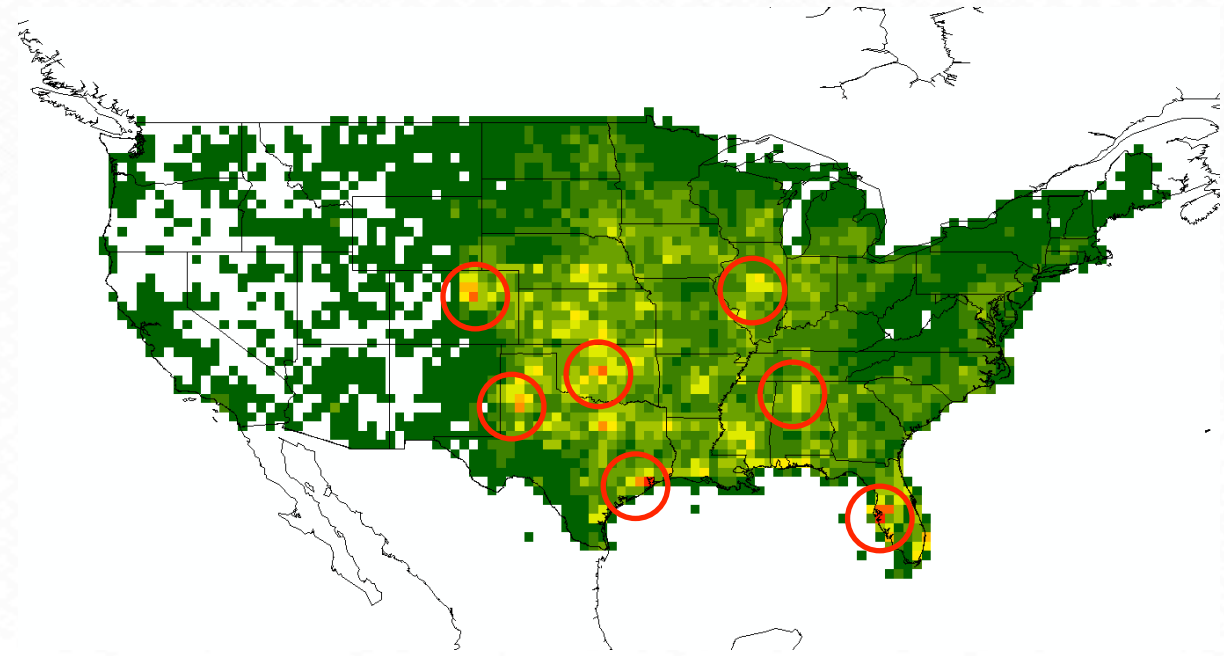
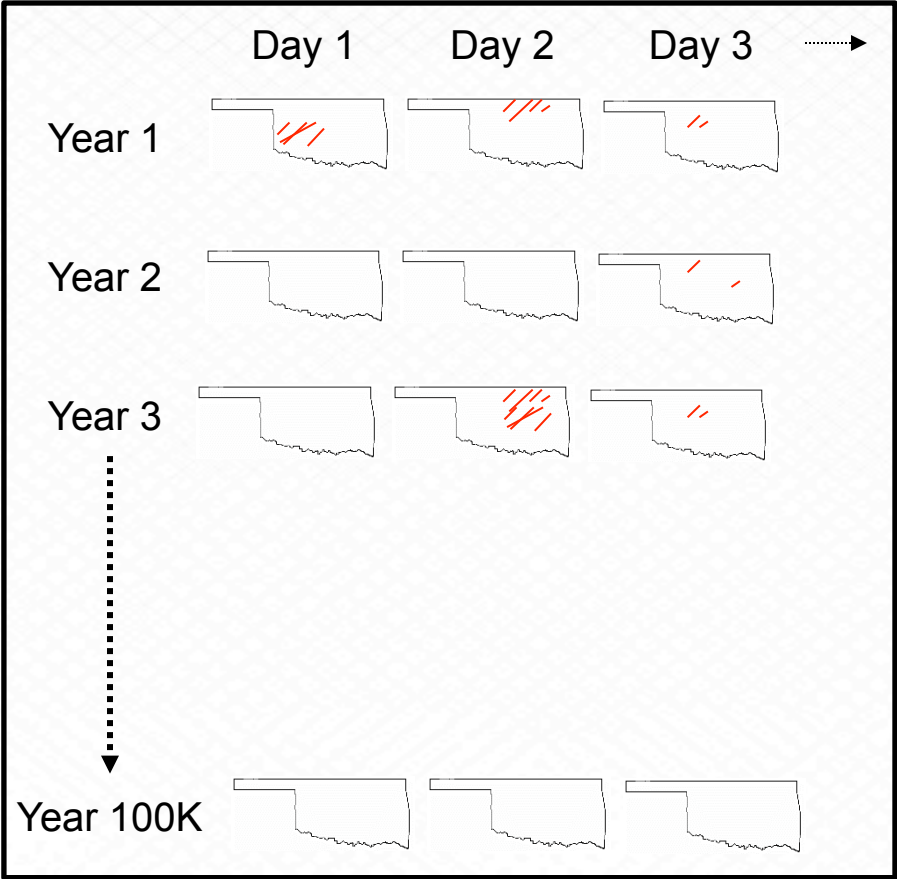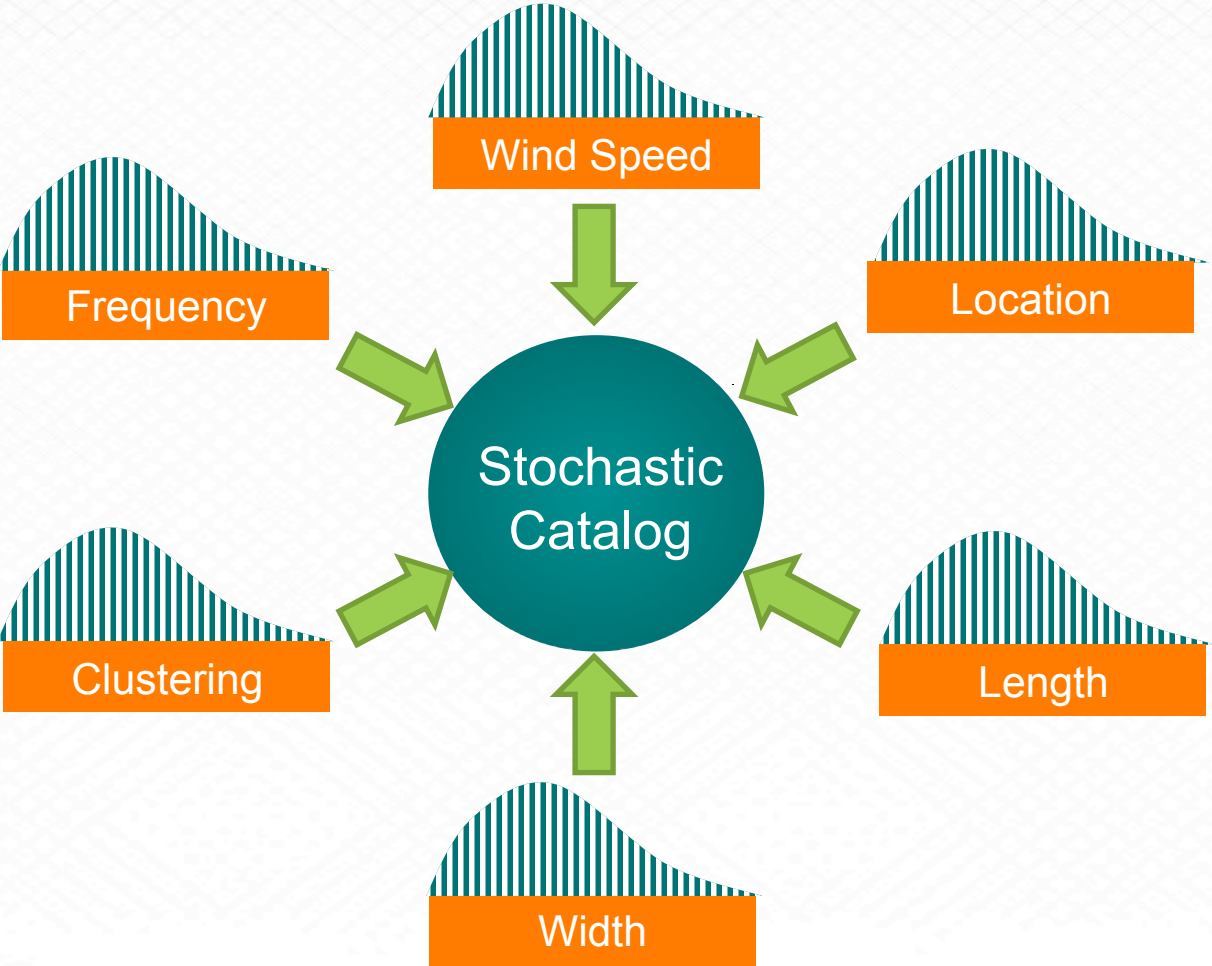# How Do We Best Leverage the Past Data We DO Have?

- – Claims Data
  - • Exact Losses
  - • Sensitive to changing exposures
  - • Short Experience

- – Tornado Observations
  - • Longer time frame (1950-present)
  - • Various Biases (eye-witness based)
  - • Inconsistent reporting procedures

- – Engineering
  - • Controlled damage studies, but often scaled
  - • Typically "pristine" (nature rarely is!)

Science · Claims · Engineering

Catastrophe Models

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The Basic CAT Modeling Framework

Event Generation

Intensity Calculation

Exposure Information
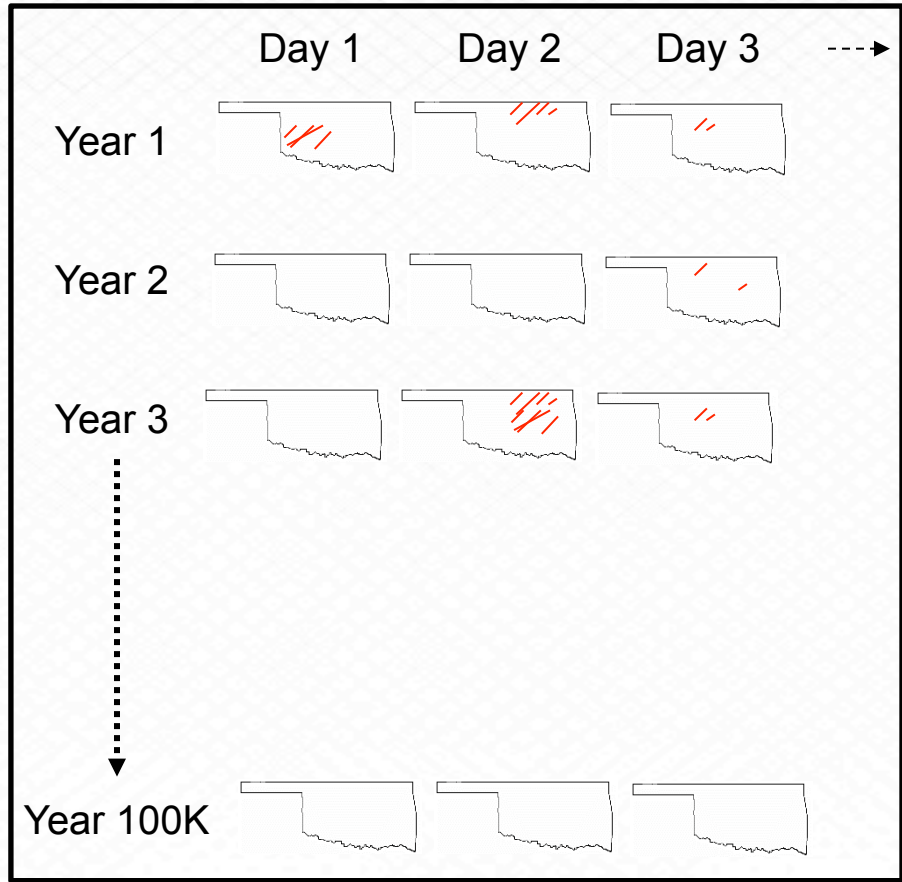
Damage Estimation

Policy Conditions

Loss Calculation

Stochastic Catalog Allows for Plausible, Yet Unrealized Events
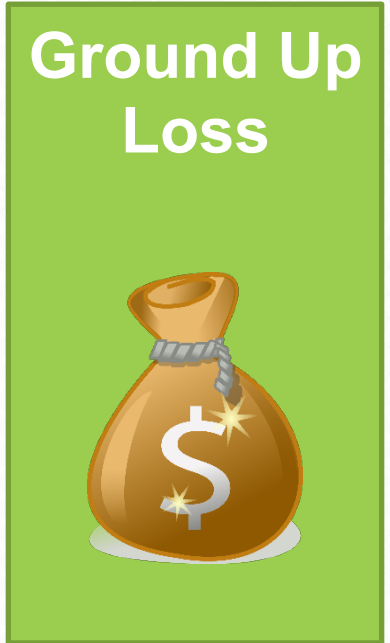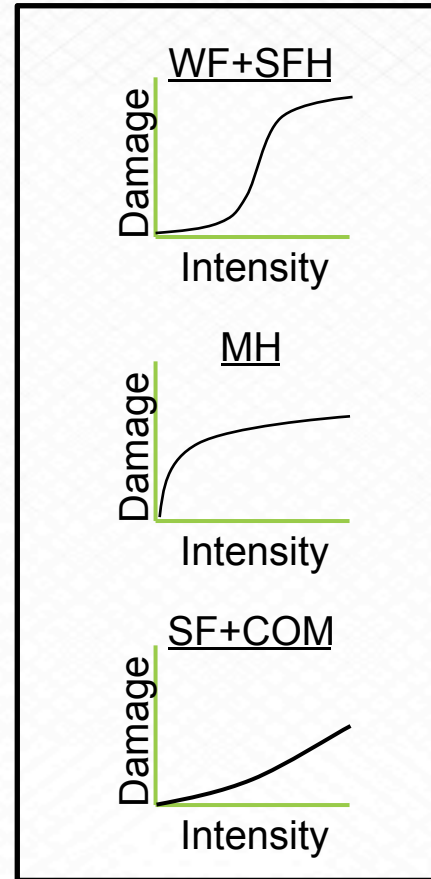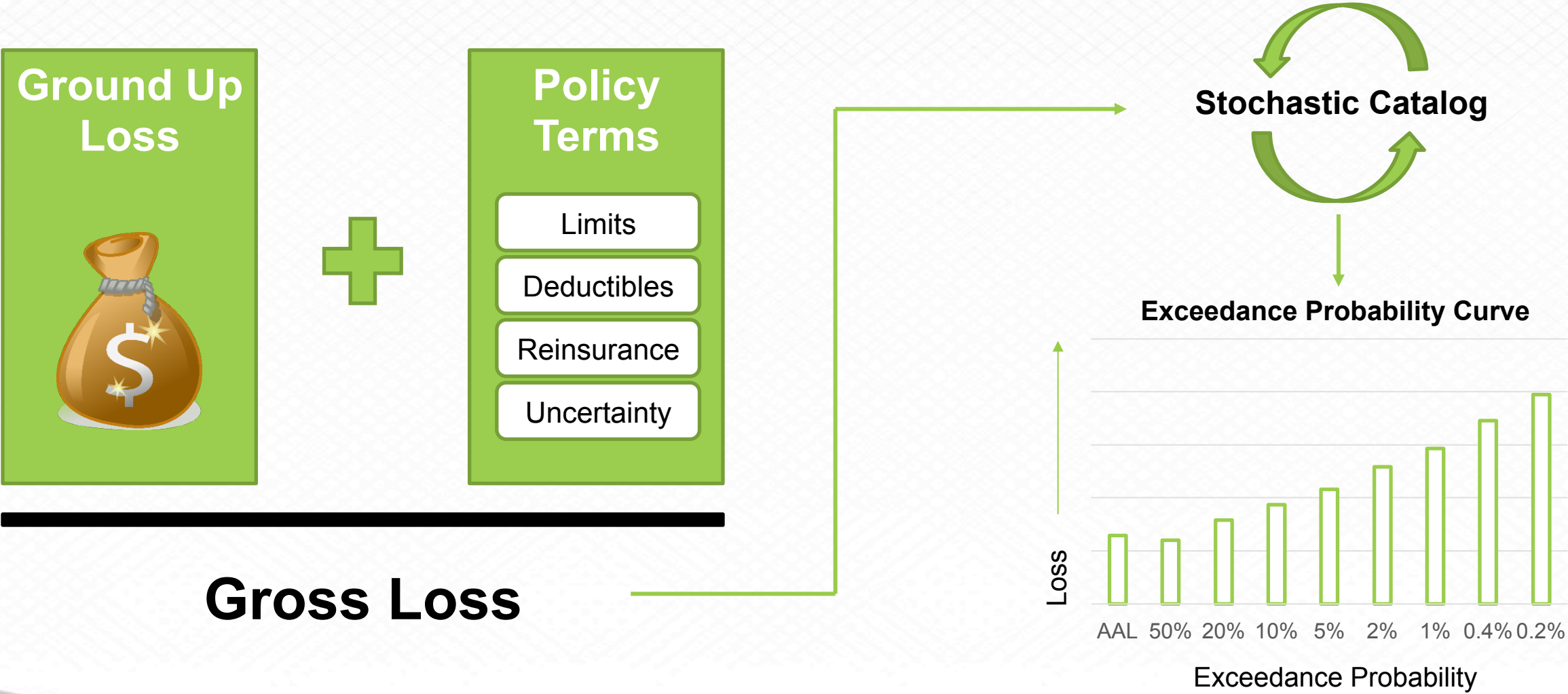

100K Iterations of Plausible Activity

CAT Models Translate Hazard into Damage

100K Iterations of Plausible Activity

CAT Models Translate Damage into Probabilistic Loss Metrics

Ground Up Loss

+

Policy Terms

- Limits
- Deductibles
- Reinsurance
- Uncertainty

Gross Loss

Stochastic Catalog

Exceedance Probability Curve

Loss

AAL 50% 20% 10% 5% 2% 1% 0.4% 0.2%

Exceedance Probability

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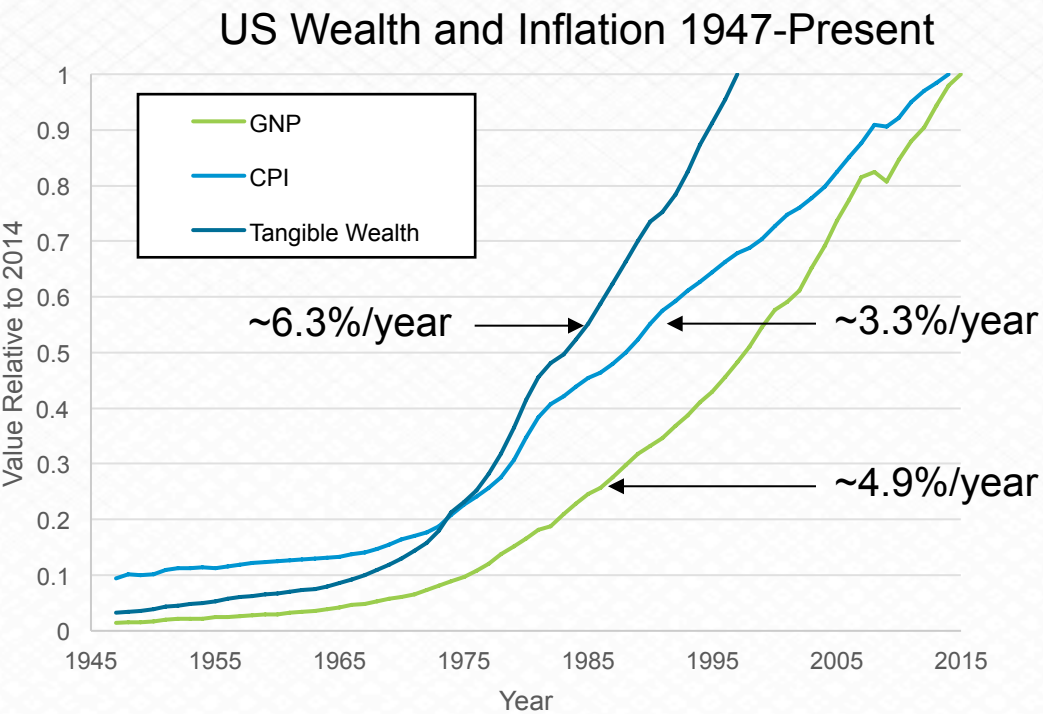# CAT Models can Also Tell Us About Specific Events

1896 St. Louis – East St. Louis Tornado

1925 Tri-State Tornado

How do we use information about individual events from the distant past to examine tornado loss potential?

Loss Trending is Not Always Straight-Forward

US Wealth and Inflation 1947-Present

Legend:
- GNP
- CPI
- Tangible Wealth

~6.3%/year
~3.3%/year
~4.9%/year

Y-axis: Value Relative to 2014 (0 to 1)
X-axis: Year (1945 to 2015)

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

*Orig. Loss ~ $12,000,000 -- 1896
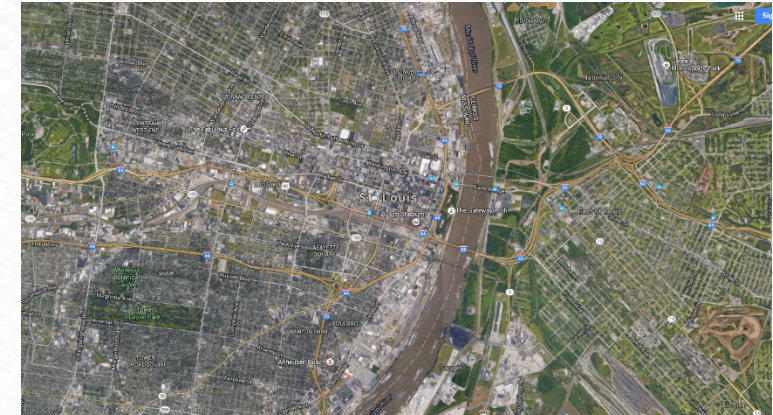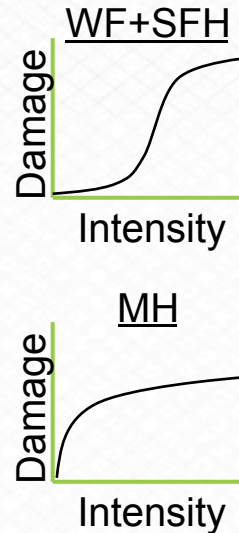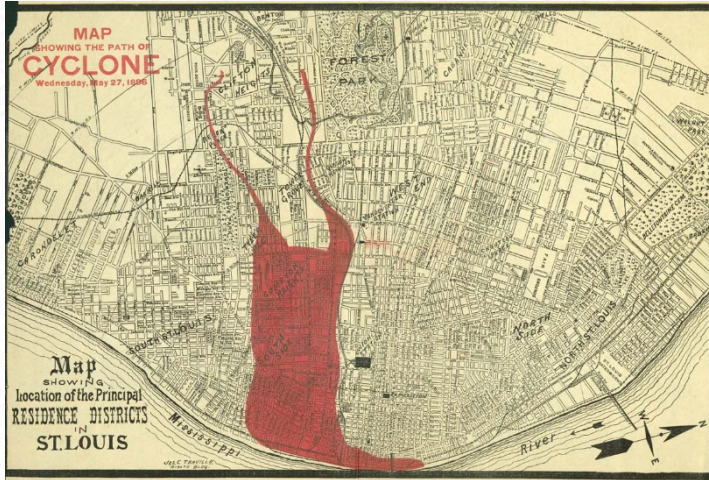

St. Louis c. 1875

St. Louis – Present Day

We Can Estimate the Loss Directly Using the Model

WF+SFH

Damage

Intensity

MH

Damage

Intensity

Upon reaching King's Highway the tornado was in a fair way to last on a voyage through the city. The scattering clouds on the edges were rapidly closing in on the central mass, and the screw shape was becoming more pronounced. From the direction it was traveling it seemed, when it passed the Insane Asylum, to be bound for Carondelet, but the strategy and ingenuity that actuated its movements came into play and steered it to a path more productive of loss of property and life.

--The Great Cyclone at St. Louis and East St. Louis

East St. Louis was More of a Challenge
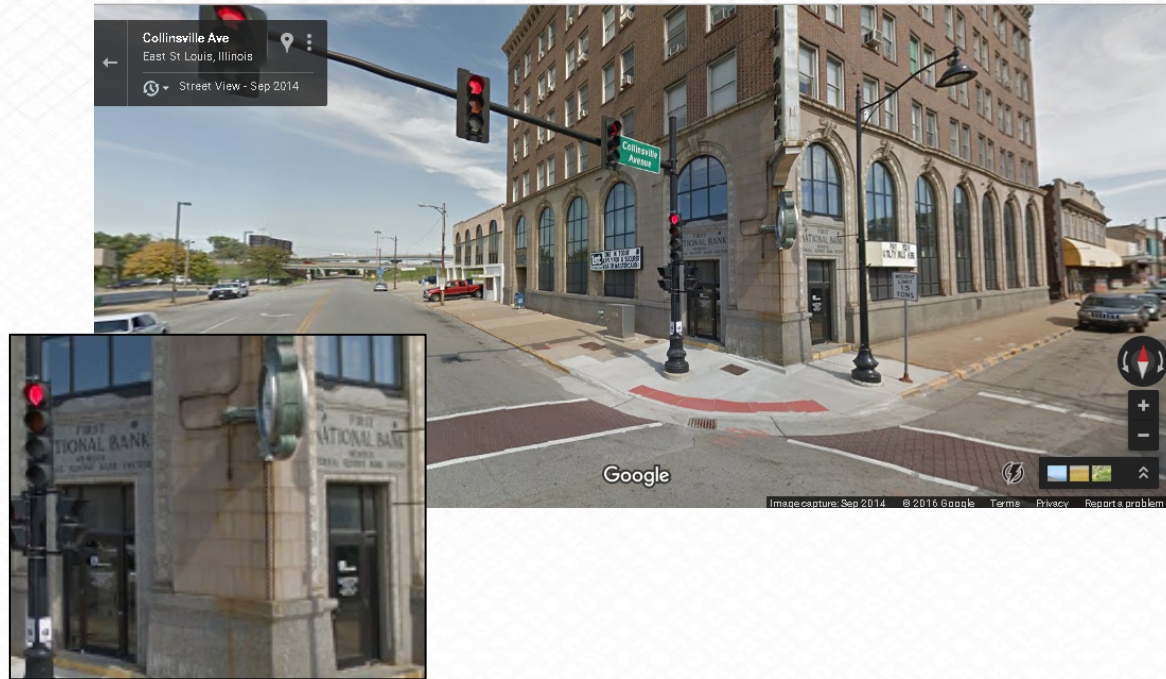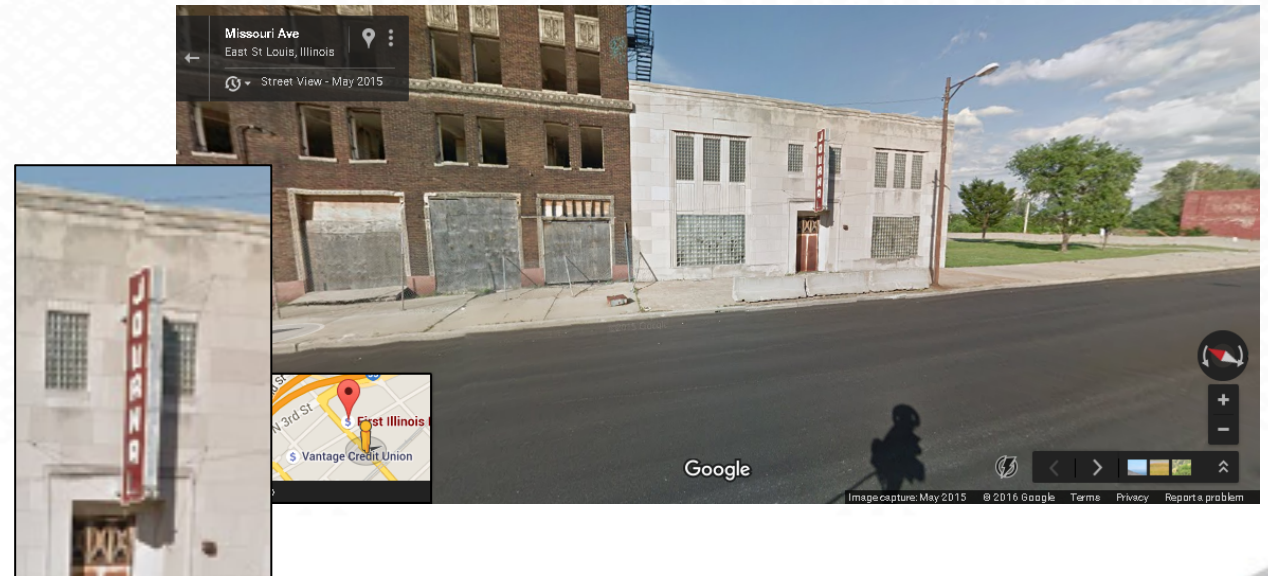
Buildings in East St. Louis:
Eads Bridge
Air Line Depot
Cairo Short Line Shops
O. & M. Round House

...

We Can Estimate the Loss Directly Using the Model
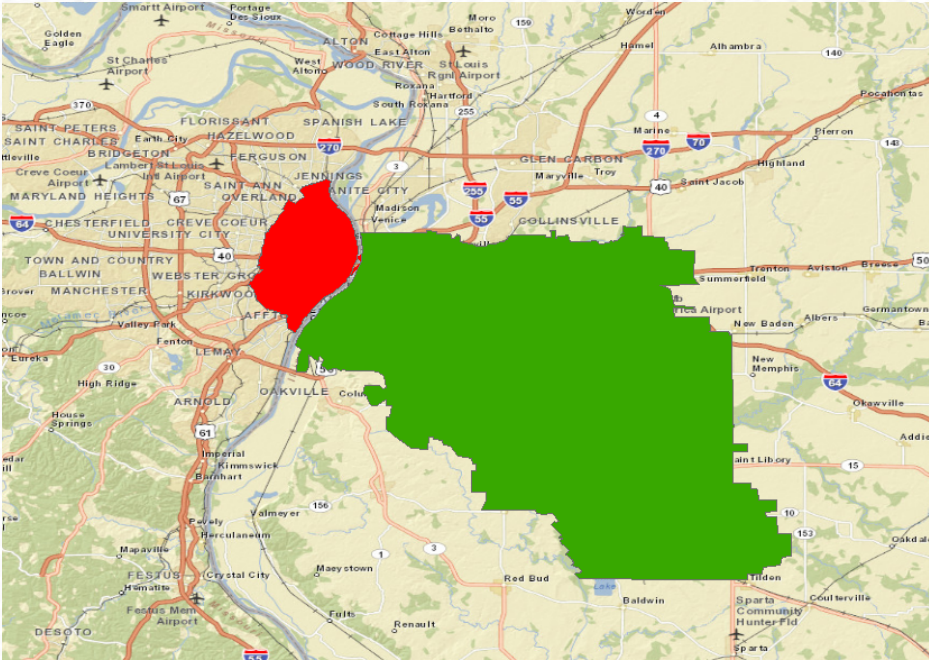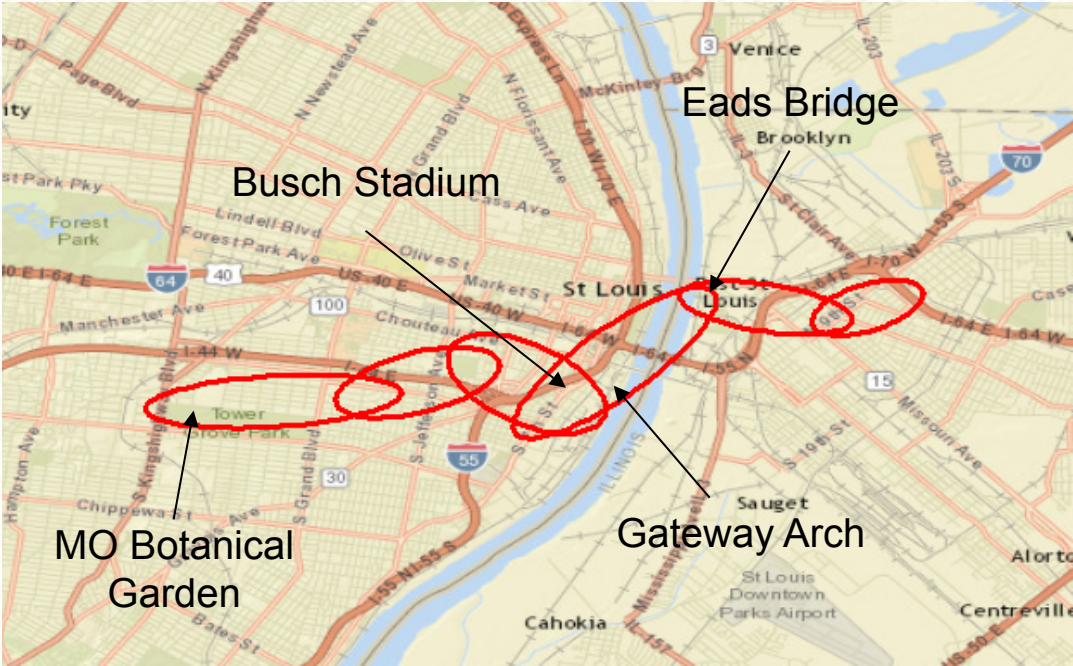
Busch Stadium
Eads Bridge
MO Botanical Garden
Gateway Arch

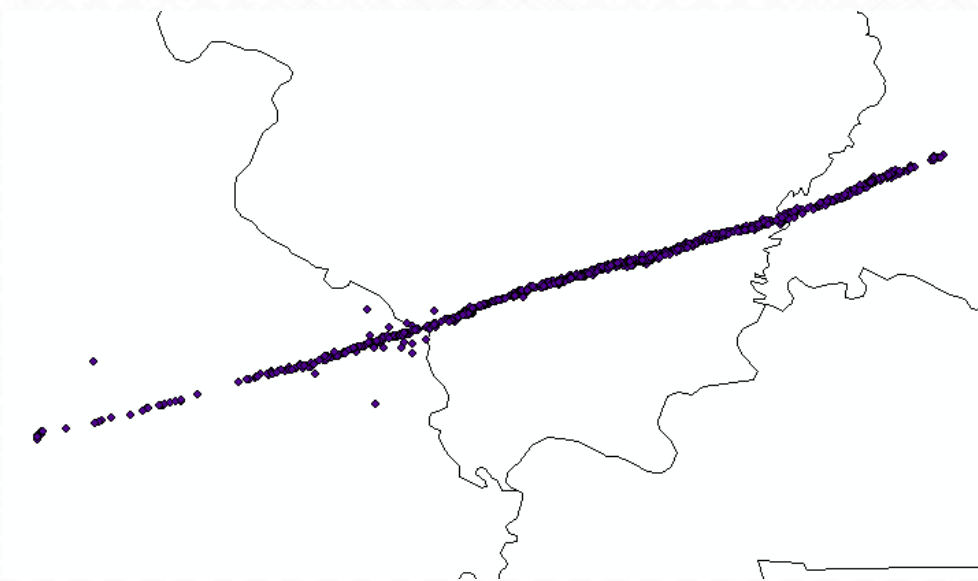| Method	Rate/yr	Loss 2014
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Tangible Wealth	6.3%	$ 15,976,856,168

*Orig. Loss ~ $12,000,000 -- 1896

The 1925 Tri-State Tornado

FIRST PICTURES OF STORM DISASTER
HERALD CHICAGO EXAMINER

FRIDAY, MARCH 20, 1925.

1,000 DEAD, 3,000 HURT **LATEST TOLL OF TORNADO**

In the Twirkling of an Eye, Murphysboro Was No More

1925 Tri-State Tornado

Damage Descriptions	Damage Degree	Upper	Lower	Average
All buildings destroyed. Cows blown away.	Complete Damage	113	198	155.5
All buildings flattened	Complete Damage	127	198	162.5
All trees blown down or severely damaged	Complete Damage	76	167	121.5
All trees were blown down in the woods	Complete Damage	76	167	121.5
Almost totally destroyed but one room standing	Complete Damage	127	178	152.5

Johns, Burgess, Doswell , 2013

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Converting Damage Descriptions to Intensities

General Keywords for Houses
1. Outbuildings, Barns, Sheds
2. House Damaged
3. House Destroyed
4. House Blown Down
5. House Blown Away

Losses for the 1925 Tri-State Tornado

Low	$ 3,650,808,480
Avg	$ 5,783,880,182
High	$ 6,773,588,918

EF-Scale Degree of Damage – Single Family Residence

Typical Construction
- Asphalt shingles, tile, slate or metal roof covering
- Flat, gable, hip, mansard or mono-sloped roof or combinations ther
- Plywood/OSB or wood plank roof deck
- Prefabricated wood trusses or wood joist and rafter construction
- Brick veneer, wood panels, stucco, EIFS, vinyl or metal siding
- Wood or metal stud walls, concrete blocks or insulating-concrete p
- Attached single or double garage

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors and windows	96	79	114
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward; failure of porch or carport	97	81	116
5	Entire house shifts off foundation	121	103	141
6	Large sections of roof structure removed; most walls remain standing	122	104	142
7	Exterior walls collapsed	132	113	153
8	Most walls collapsed, except small interior rooms	152	127	178
9	All walls	170	142	198
10	Destruction of engineered and/or well constructed residence; slab swept clean	200	165	220

* DOD is degree of damage

# So…What Can the Past Tell Us?

What can the past tell us about tornado loss potential?

- A highly biased view if we are not careful
- A probabilistic view of loss if we are careful
- A view into how bad things could have been given today's exposure

How Will Tornado Risk Change in the Future?

Largely Dependent on 2 Main Factors:
Exposure Growth
and
Changing Severe Thunderstorm Distributions

US Growth Trends
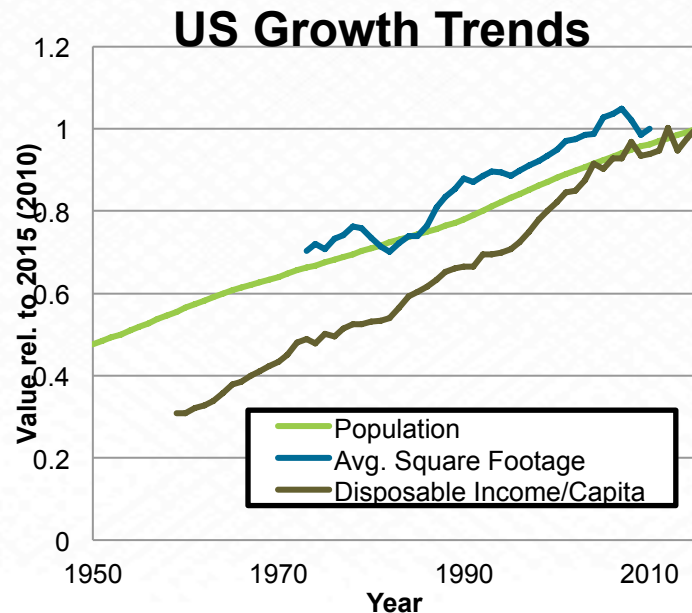
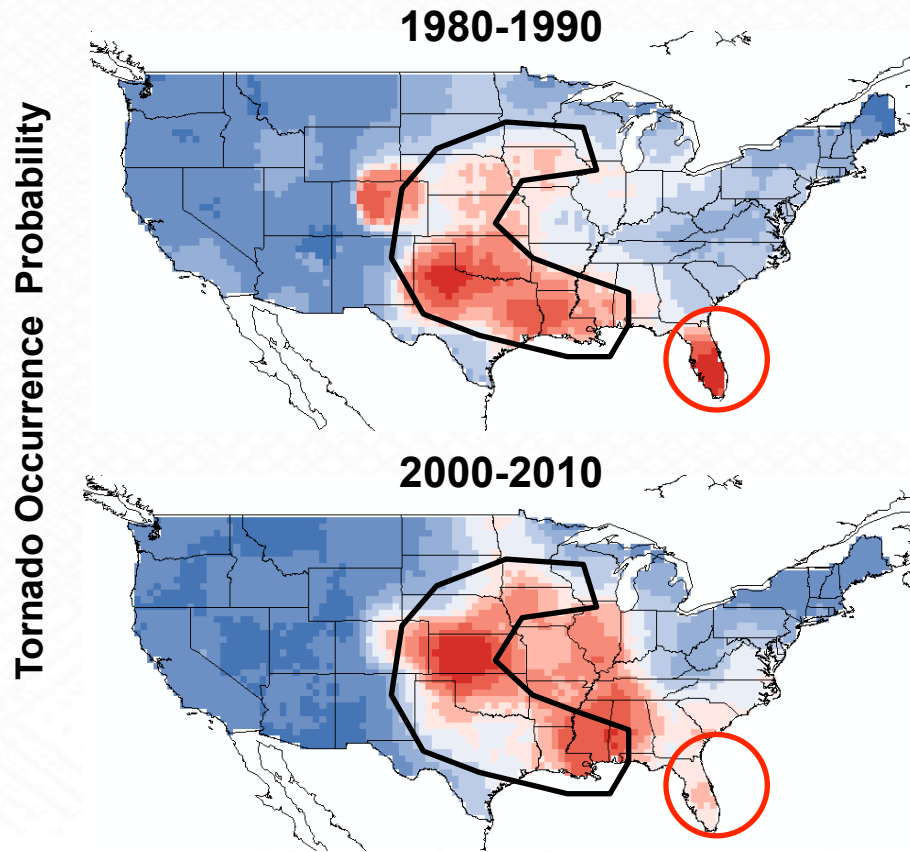

Average Change Per Year, 2014-2024

Disposable Income Per Capita: +3.6%
Population   +0.7%
Avg. Square Footage   +1.2%
Inflation   +3.2%

What About Changing Tornado Distributions?

Decadal Variability is Regionally Dependent

1980-1990

Tornado Occurrence Probability

2000-2010

What drives the change in seasonal tornado activity?
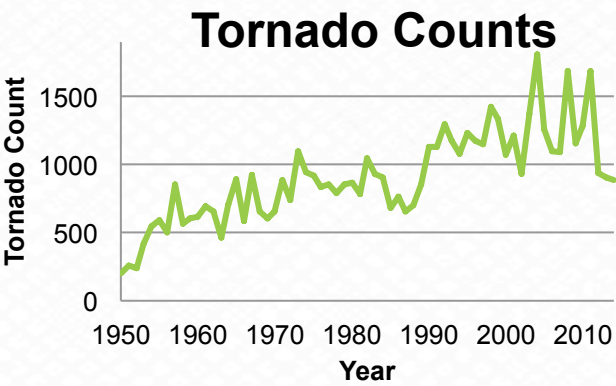
To Understand Tornadoes You Must Understand the Environment

– Where CAPE, wind shear, and lift come together, there is tornado potential

– In the US, this happens most often in the Southern Great Plains:

  • Jet Stream (shear), Warm Southerly Flow (CAPE), and the Dry line (lift)

– Understanding how these "ingredients" change is key to understanding ST activity!

Tornado (409)
Hail (824)
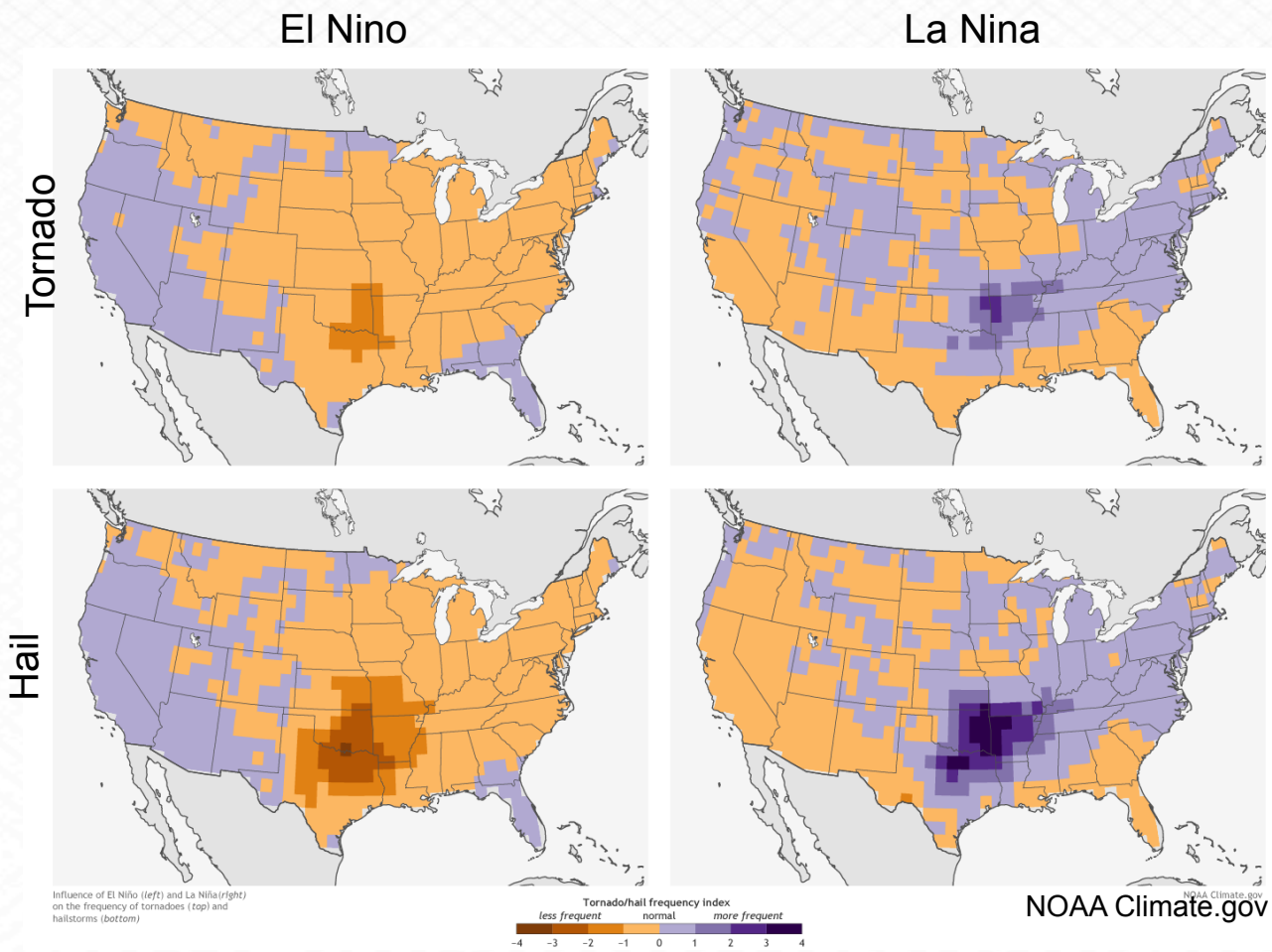Wind (908)

Potent Spring-Time Jet Stream
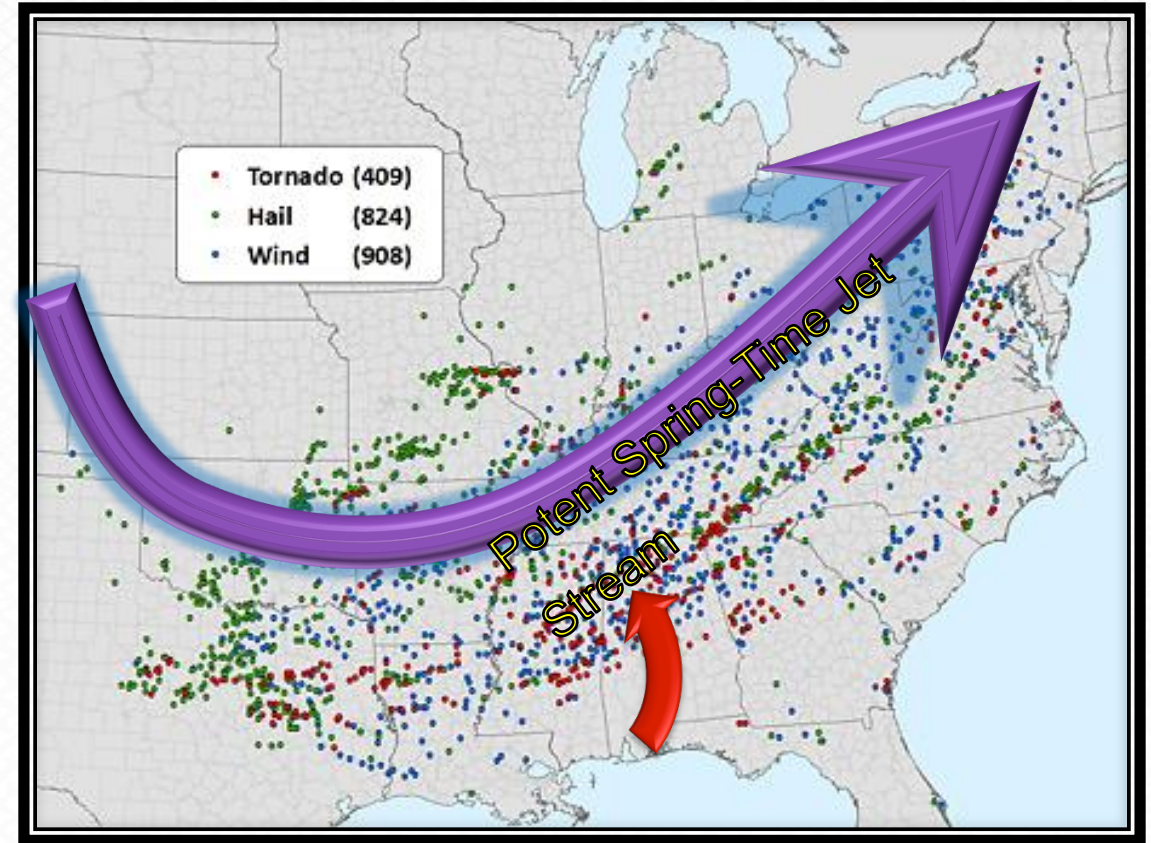
How Will These Parameters Change in the (Near) Future?

Global Climate Signals (ENSO, MJO, PDO, etc) have the potential to influence activity

Large Inter-annual variability makes it difficult to determine significant relationships
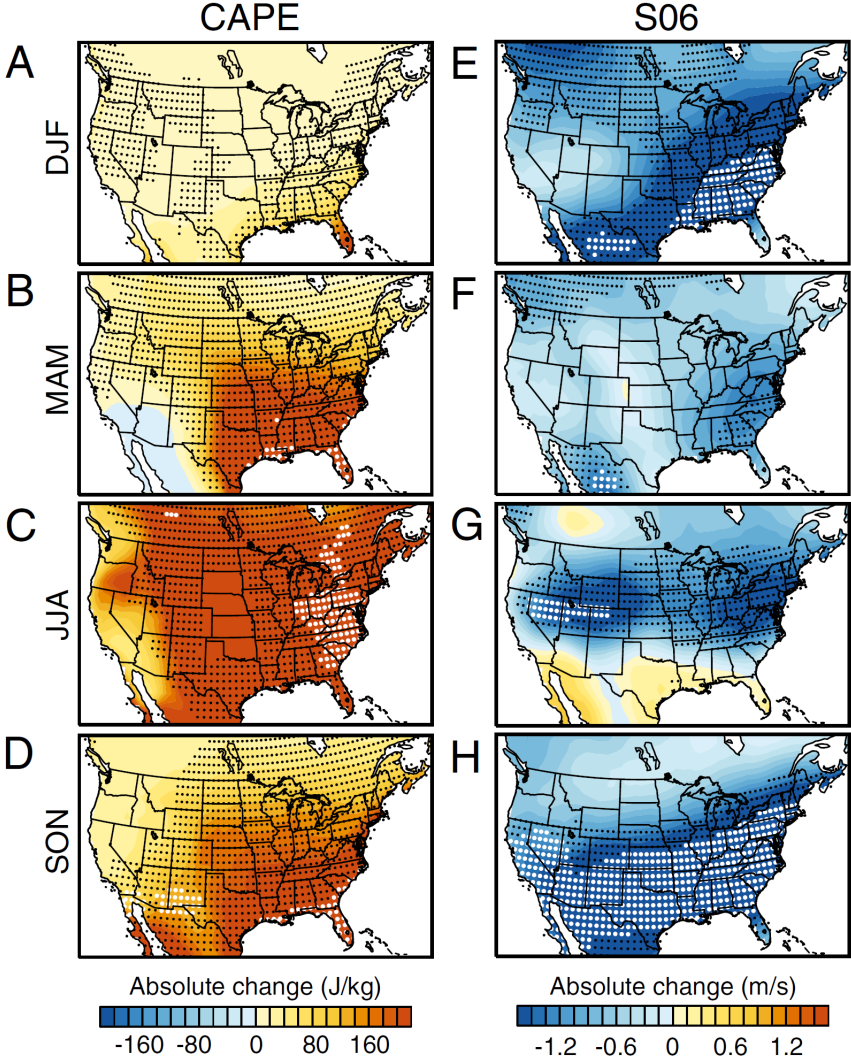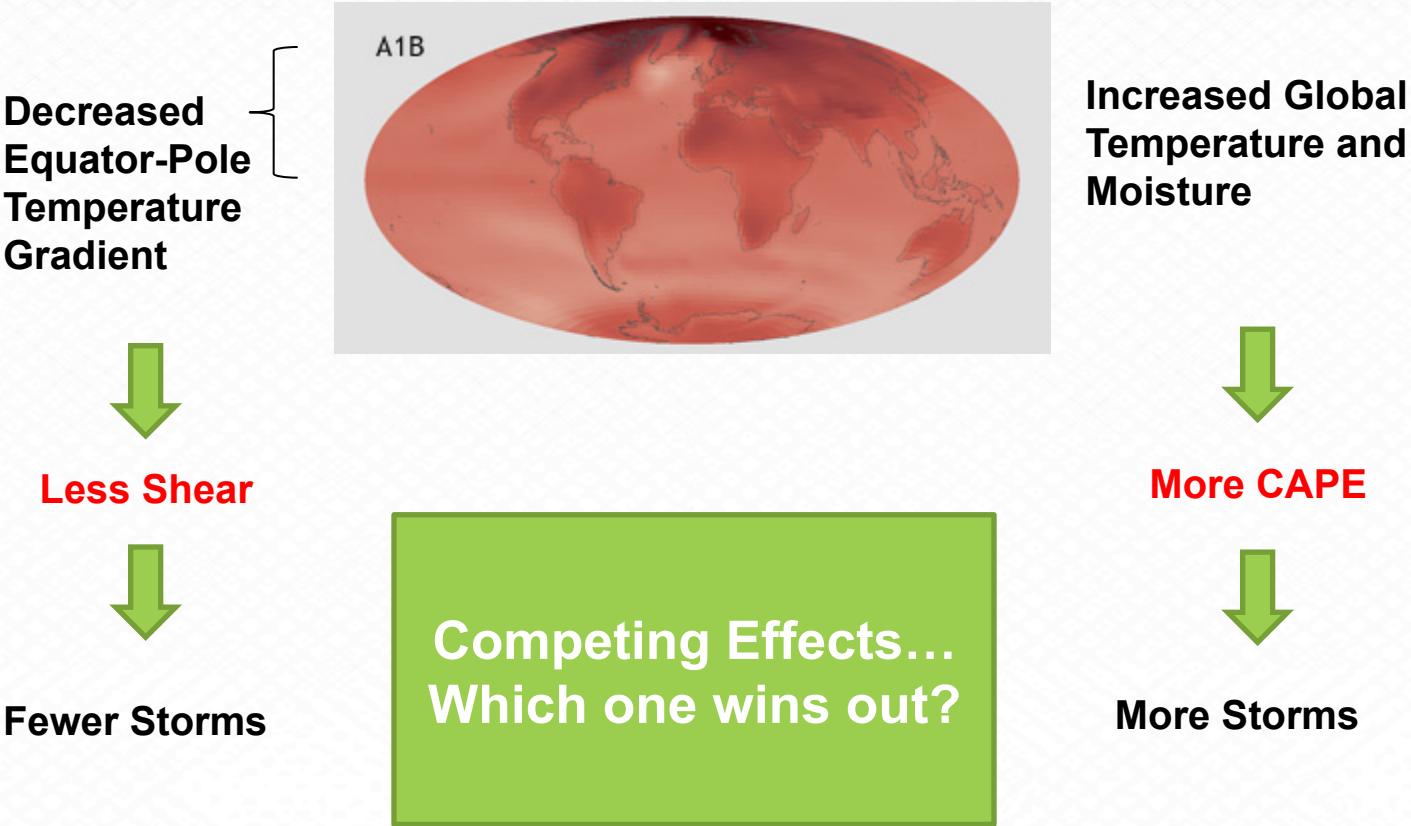

Tornado Counts

Note: These are favorable "environments", which still suffer from the "initiation problem"

El Nino

La Nina

Tornado

Hail

Influence of El Niño (*left*) and La Niña (*right*) on the frequency of tornadoes (*top*) and hailstorms (*bottom*)

Tornado/hail frequency index

less frequent   normal   more frequent

-4   -3   -2   -1   0   1   2   3   4

NOAA Climate.gov

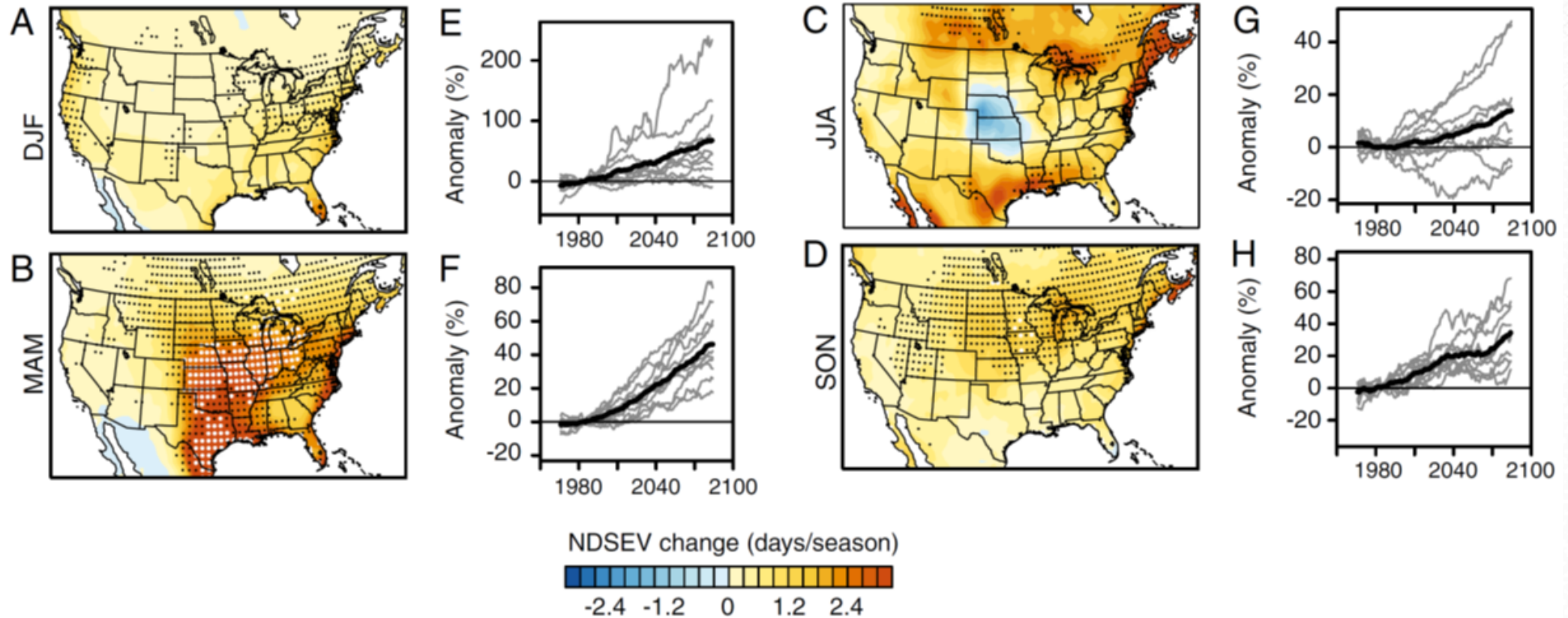Tornado and Hail Environment Frequencies over March, April, and May

More Broadly, What About Climate <u>CHANGE</u>?

Decreased Equator-Pole Temperature Gradient

A1B

Increased Global Temperature and Moisture

↓

Less Shear

↓

Fewer Storms

**Competing Effects…
Which one wins out?**

↓

More CAPE

↓

More Storms

CAPE

S06

A | DJF

E

B | MAM

F

C | JJA

G

D | SON

H

Absolute change (J/kg)
-160 -80   0   80   160

Absolute change (m/s)
-1.2 -0.6   0   0.6   1.2

Diffenbaugh et. al, 2013

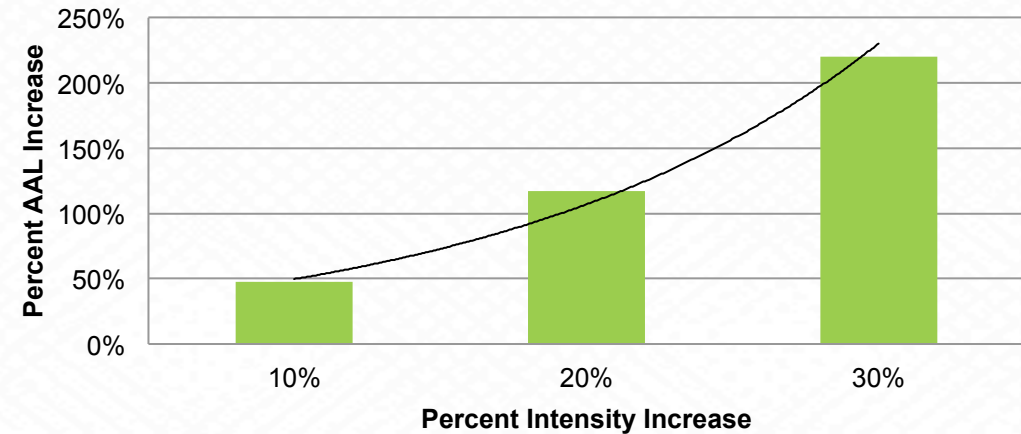BUT Remember… this is only "ENVIRONMENTS"

What Would a Modest Increase in Intensity Mean for Losses?

- – Energy delivered can be non-linear with "intensity"
  - Ex: Hail Diameter

- – Damage can be non-linear with energy delivered
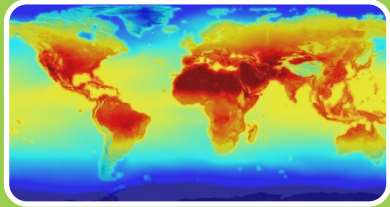 - Ex: Impact-rated shingles

Change in Average Annual Loss for +10% Intensity

USA	48%
OK	35%
TX	39%
MA	56%

Percent Change USA AAL

The Future and Beyond…
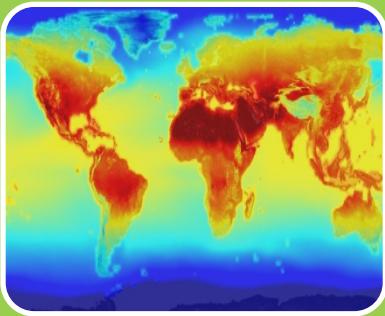
What does the future have in store for us?

- Even Bigger Houses!
- Continued Research on Teleconnections
- Possibly More Frequent (and more damaging) Severe Thunderstorms

The 2 "Whats" We Answered Today

What can the past tell us about tornado loss potential?

- A highly biased view if we are not careful
- A probabilistic view of loss if we are careful
- A view into how bad things can be

What does the future have in store for us?

- Even Bigger Houses!
- Continued Research on Teleconnections
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Thank You!

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