What’s New in Catastrophe Modeling

Katie School of Insurance 2025 Spring Symposium

Karen Clark

The Innovation and Technology Leader in
Weather, Climate, and Catastrophe Risk Modeling

KCC: Innovation Leader in Weather, Climate, and Catastrophe Risk Modeling

Multidisciplinary team of PhD scientists and engineers spanning the fields of:

Atmospheric Science
Geophysics/Seismology
Hydrology
Wind engineering
Structural engineering
Earthquake engineering
Statistics/data science

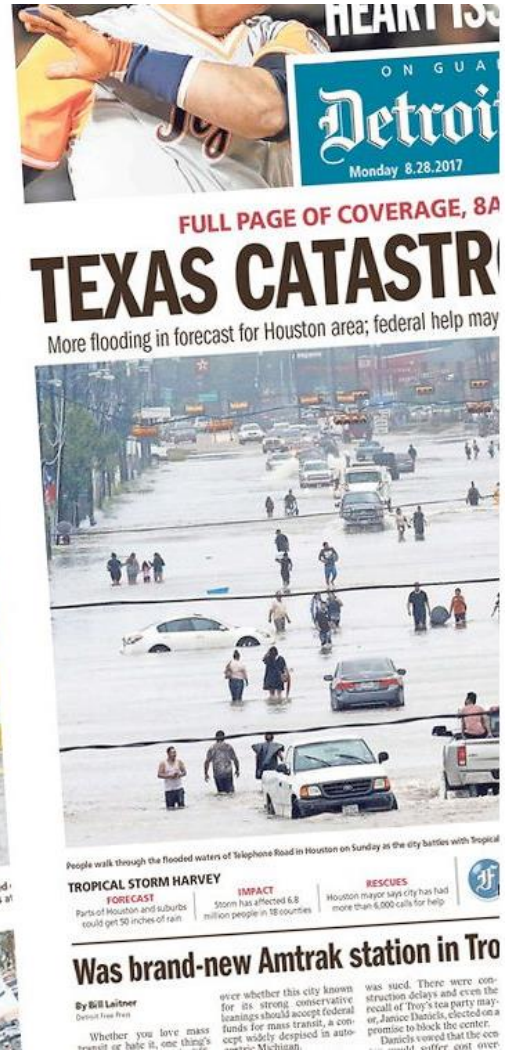
KCC delivers scientifically advanced, high-resolution, and accurate models for:

Tropical cyclones
Extratropical cyclones
Earthquakes
Severe convective storms
Winter storms
Wildfires
Floods

KCC models and software applications are used by the world's leading financial institutions

Top 10 P&C insurers
Regional and super-regional insurance companies
Reinsurers, banks, and ILS investors

Natural Catastrophes Are Increasingly Front-Page News and Causing $Multi-billion Losses



Biggest climate toll in year of 'devastating' disasters revealed

Most expensive storm cost $100bn while deadliest floods killed 1,700 and displaced 7 million, report finds

Tornadoes by the numbers: Damage reported across 14 states

At least 32 people have died as a result of the storms on March 31 and April 1.

By Meredith Deliso, Kenton Gewecke, and Morgan Winsor
April 4, 2023, 6:00 AM

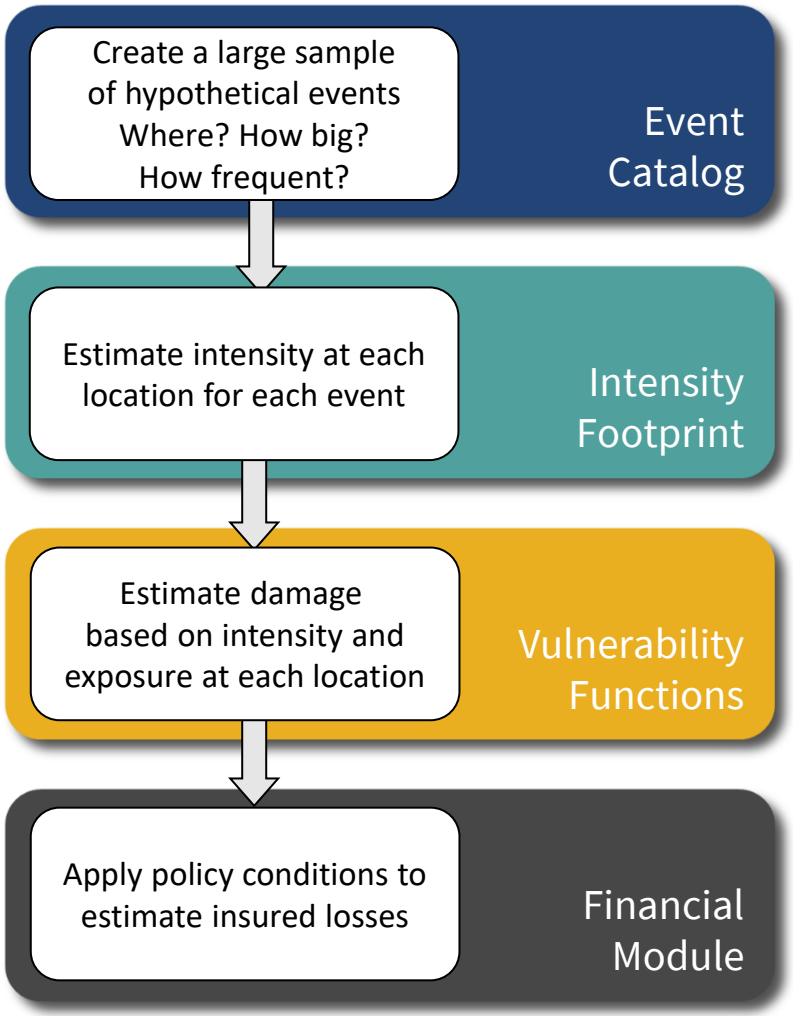
Winter Storm Elliott Intensified Into Bomb Cyclone With High Winds, Blizzard Conditions, Flooding

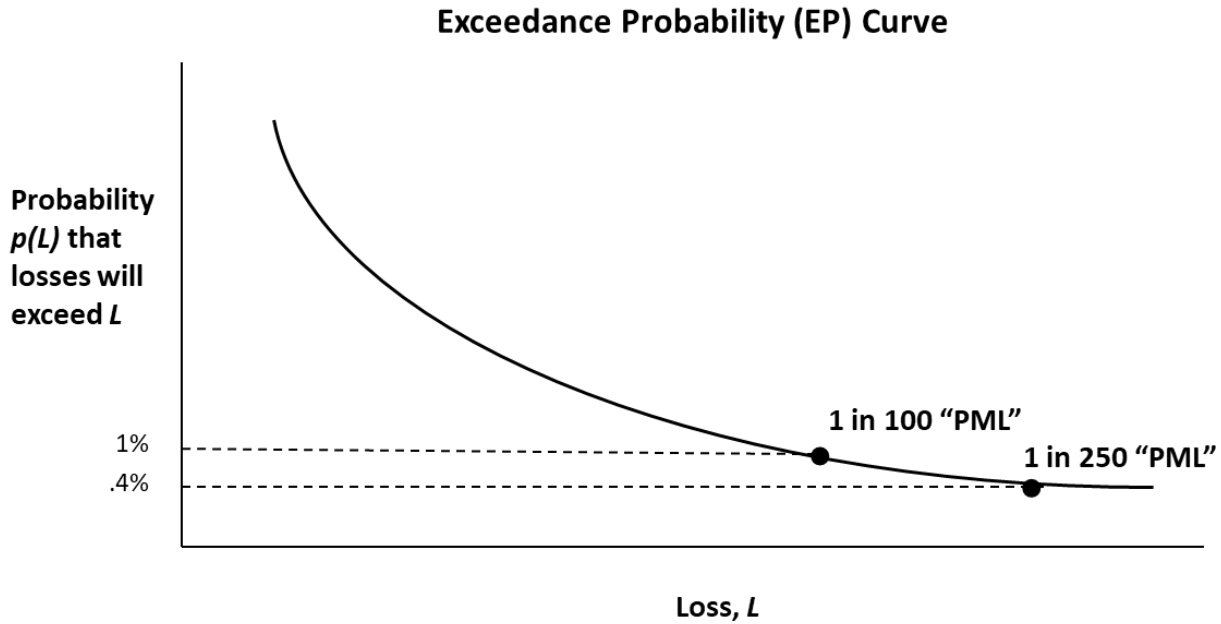
By weather.com meteorologists · December 24, 2022

What Insurance Companies Need to Know

- How likely are we to have a solvency impairing event?
- How much reinsurance do we need to buy?
- How much do we need to charge to cover our expected losses?
- Which properties are more or less vulnerable than others?
- How much business can we write in different geographical areas?

Catastrophe Modeling is the Global Standard Technology for Answering These Questions





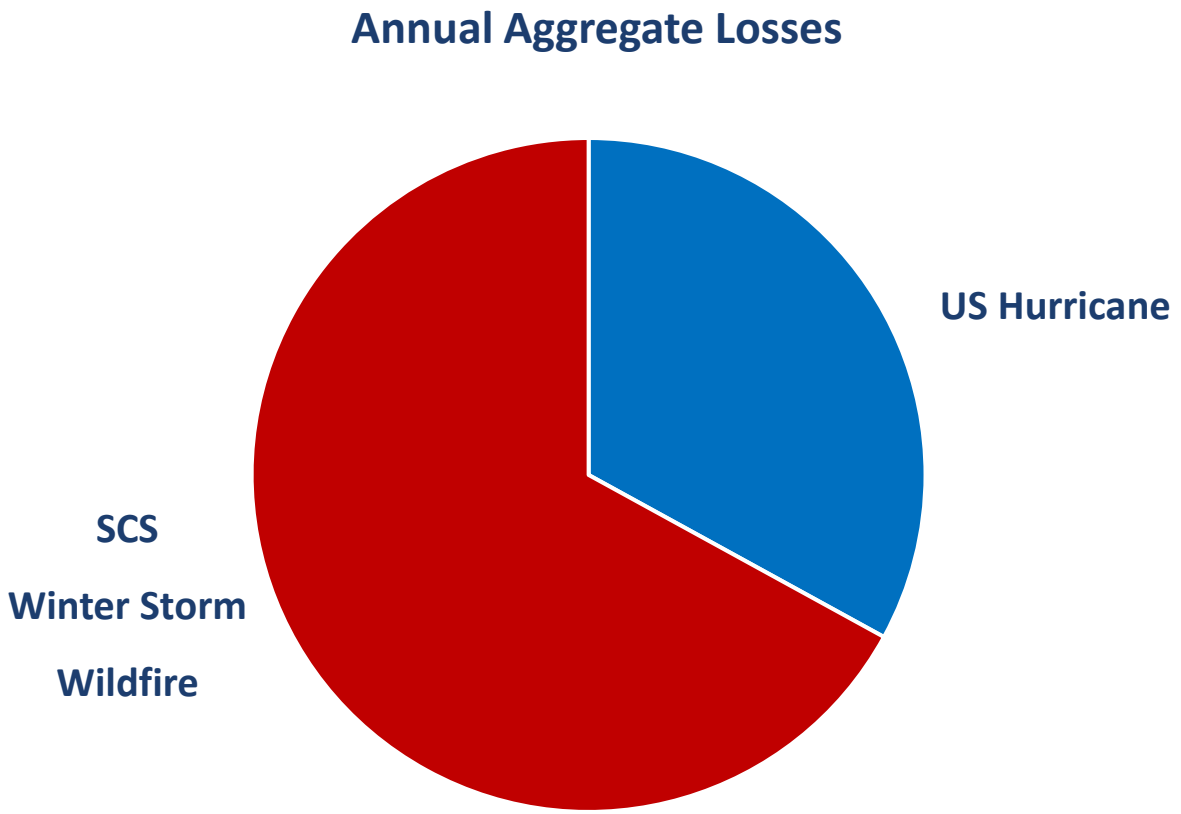
What's New: Frequency (aka Secondary) Perils Have Taken Center Stage When it Comes to Insurance Claims and Losses

Severe Convective Storms (SCS)

Wildfires

Winter Storms

AAL from SCS, Winter Storm, and Wildfire Significantly Exceed Hurricane

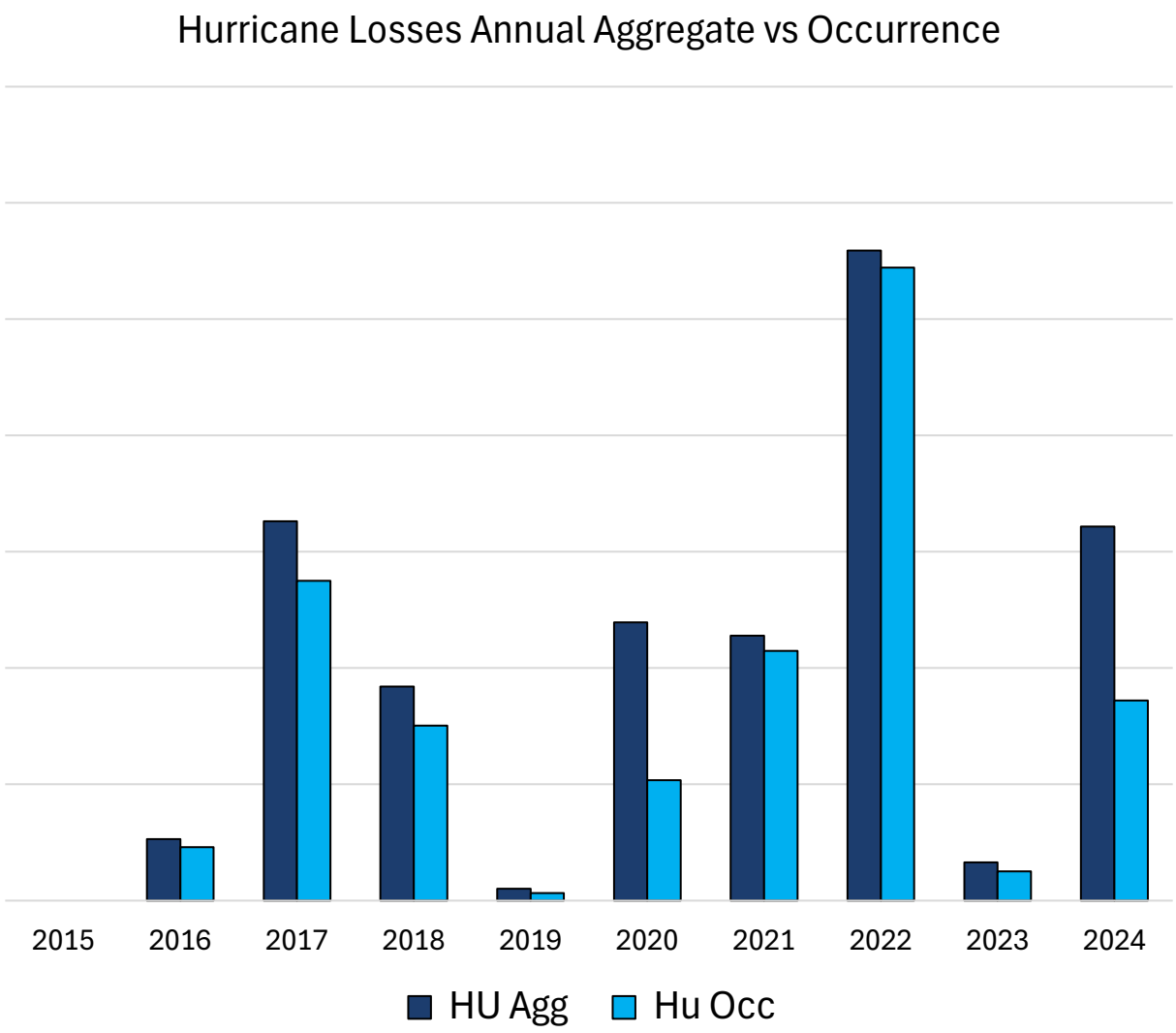


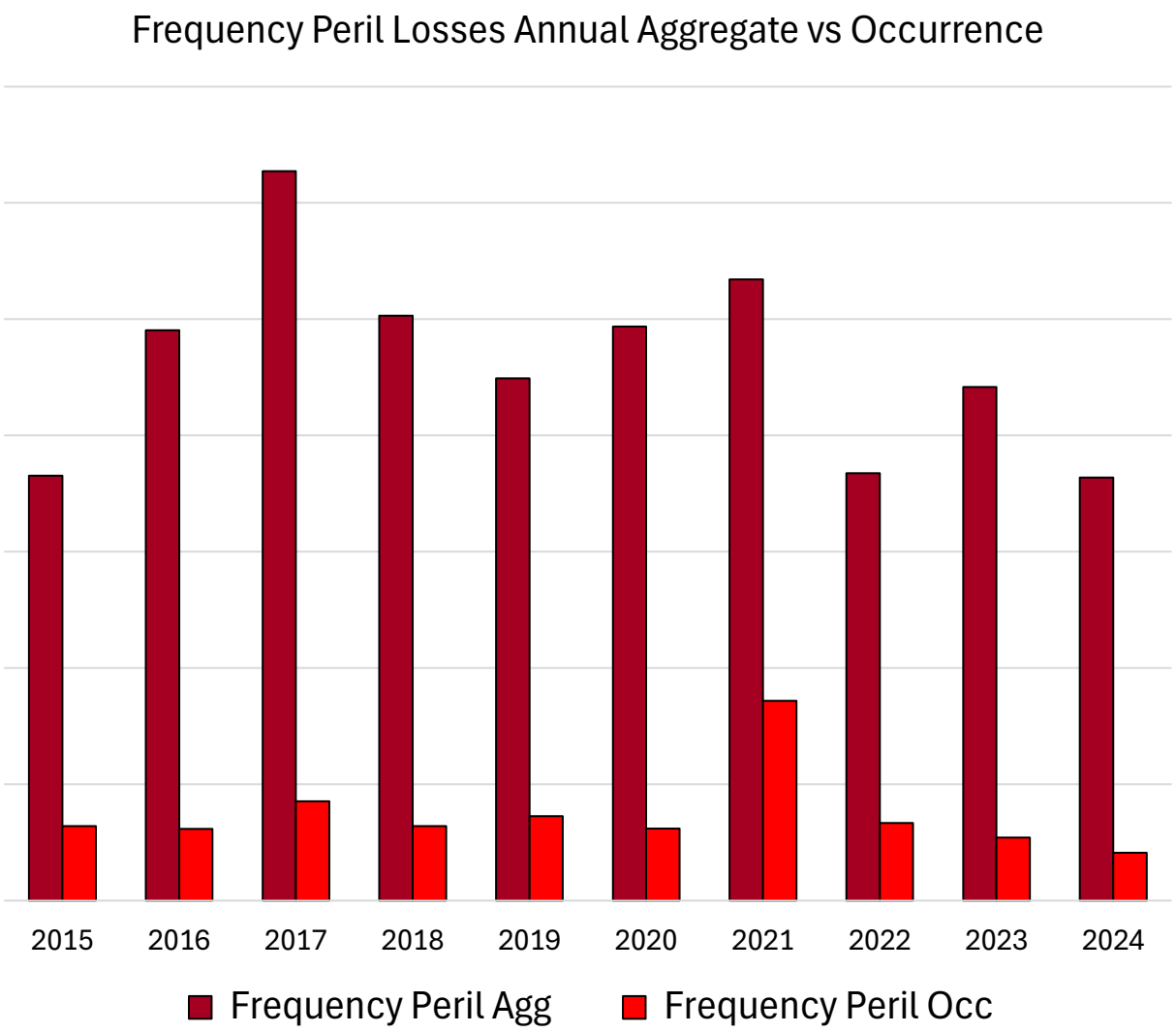
Severe Weather was a Major Reason for Company Downgrades in 2024

63% of property insurer senior executives cite the frequency and severity of weather events as their number one concern

A.M. Best

Insurers Would Like to Buy More Reinsurance to Reduce Volatility in Annual Aggregate Losses





Reinsurers Pulling Back Capacity for the Frequency Perils

Rising Costs of Secondary Perils Force Reinsurers to Require Higher Attachment Points – Insurance Journal - 1/23

The increased caution from reinsurers has left primary insurers with higher risk retentions for secondary peril events – Fitch Ratings - 9/24

SCS losses forcing mutuals to take drastic action as reinsurers retrench – The Insurer - 11/23

"Insurers are retaining more risk. In '23 / '24, estimated at ~ 90% of loss. Before '23, reinsurers would often share a higher proportion of insured loss ~ 50/50."

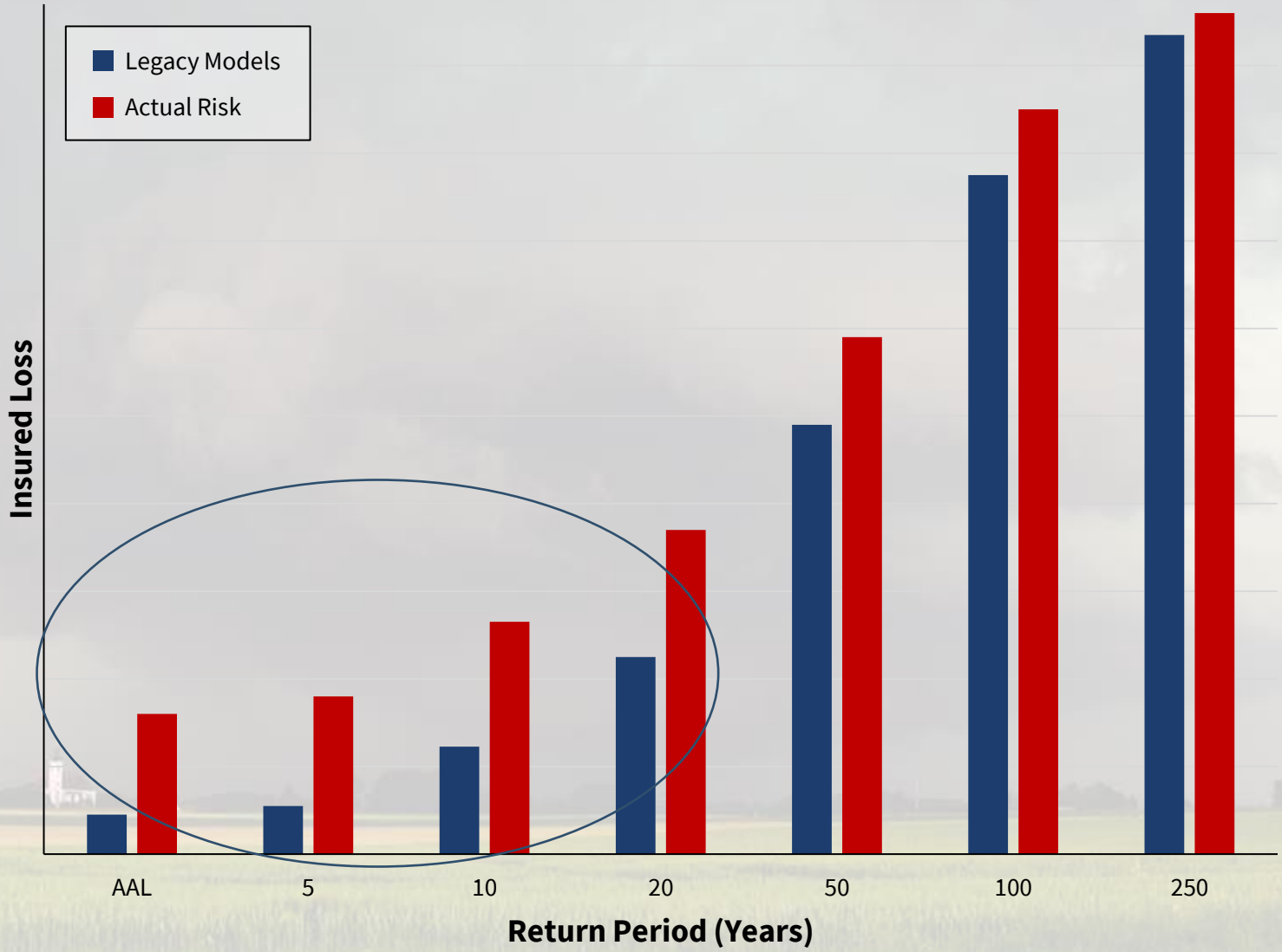
– Insurance Journal - 2/25

Why? Increasing Demand Should be an Opportunity for Reinsurers

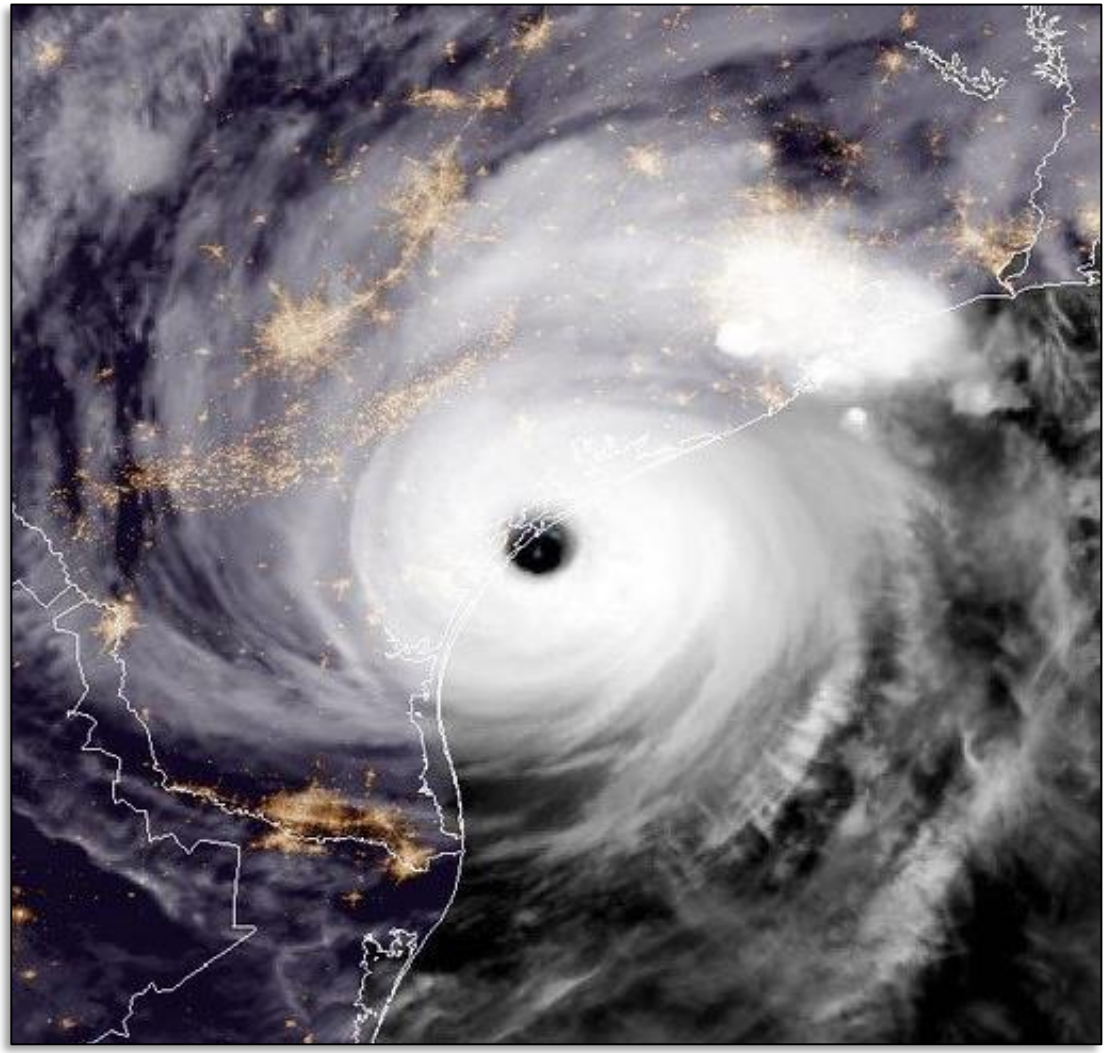
There’s no such thing as a bad risk

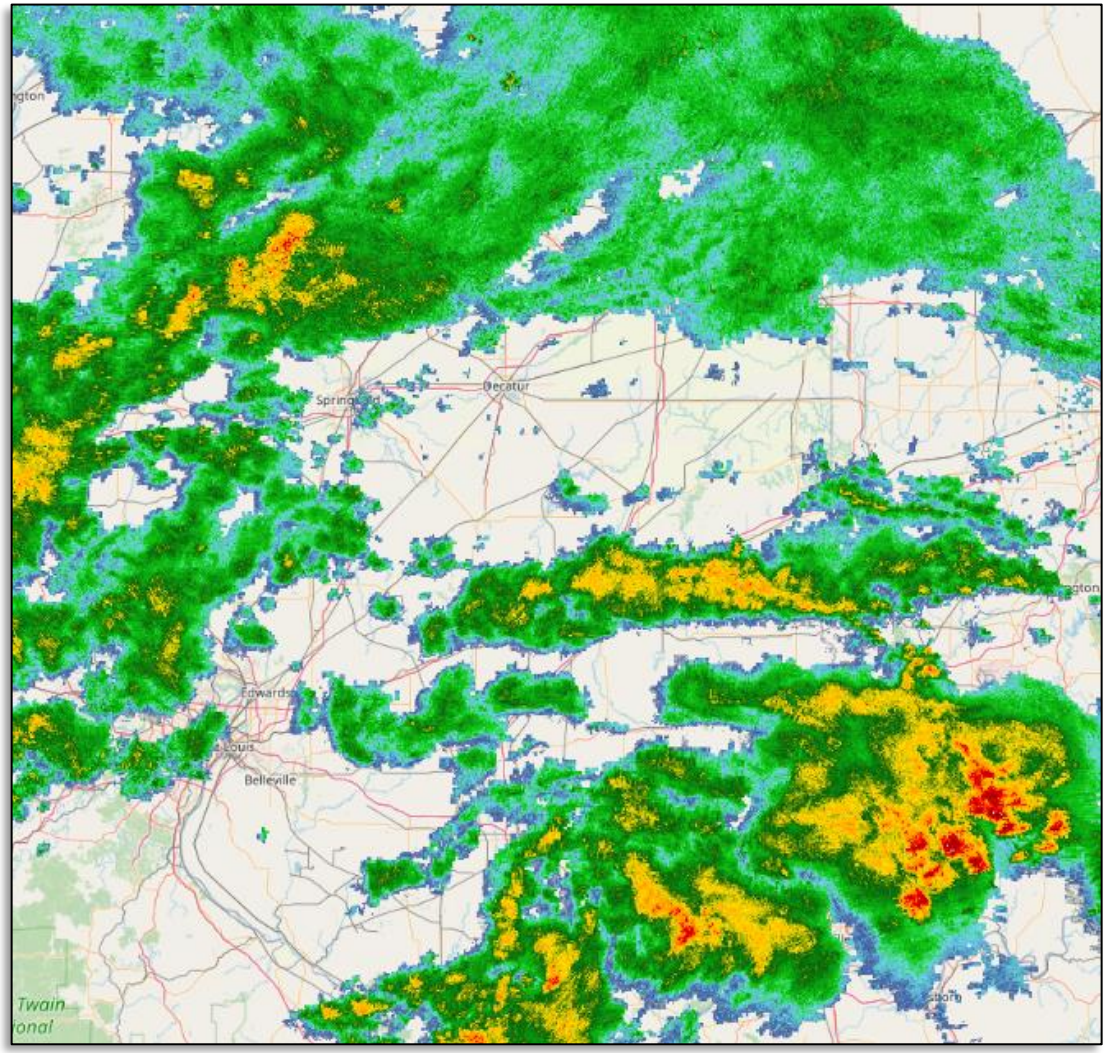
only a bad price!

Frequency Perils Dominate the Lower Return Periods—Where First Generation Models Miss



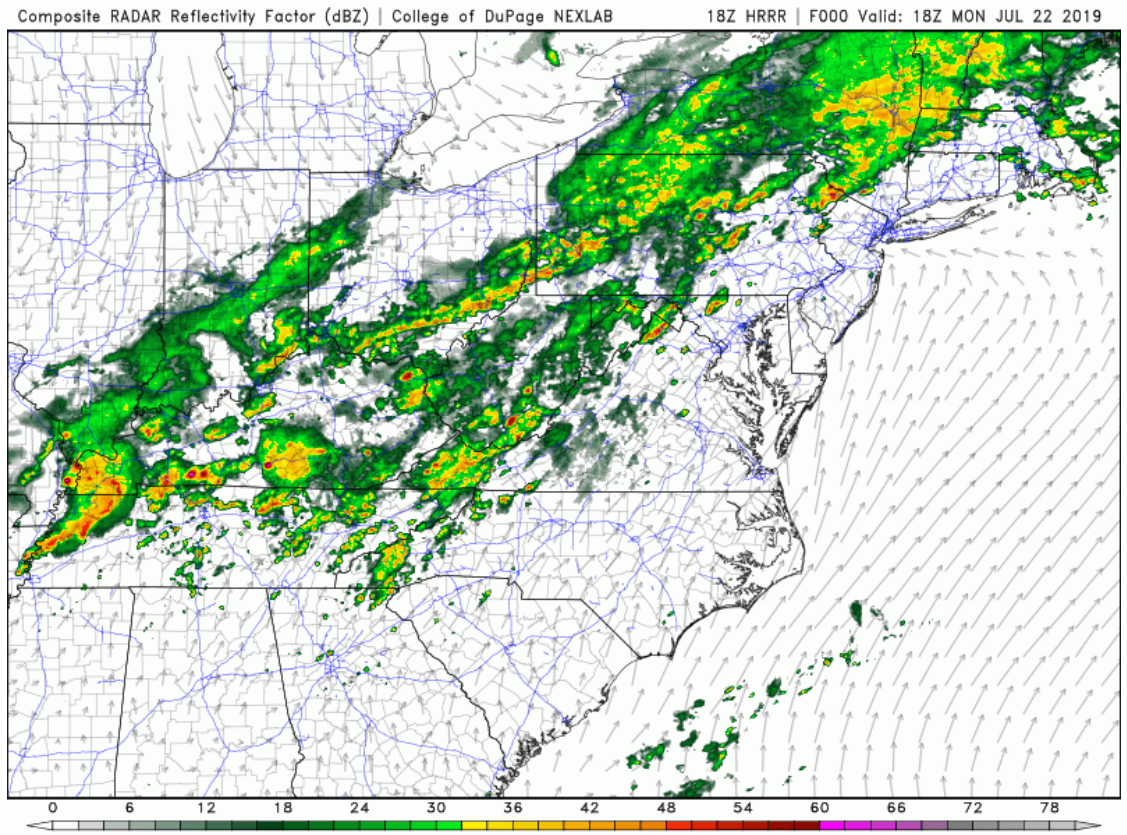
Why Severe Convective Storms Are More Challenging to Model than Hurricanes



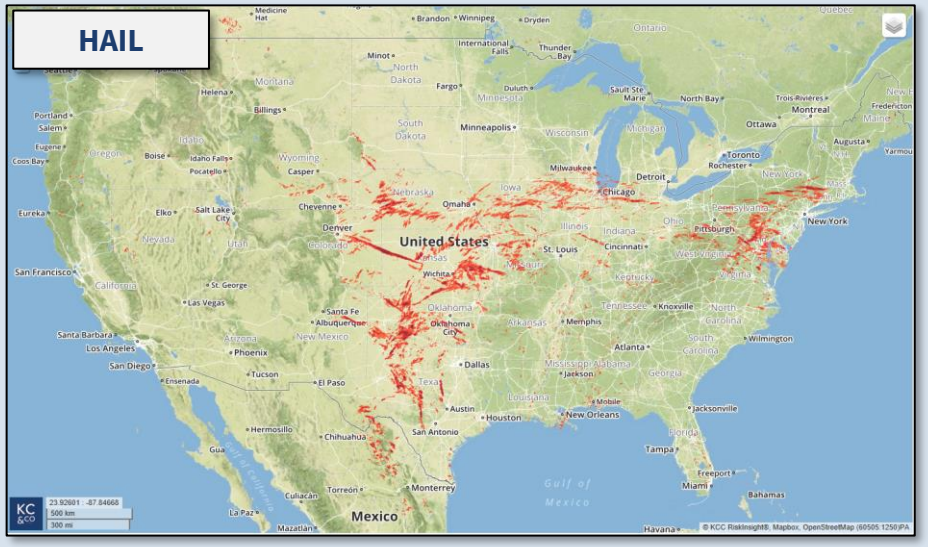


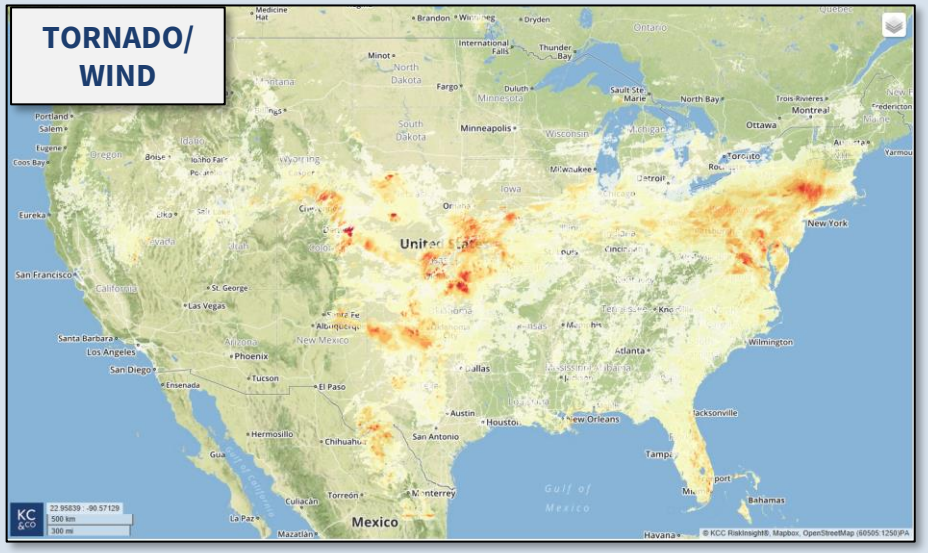
How KCC Scientists Built an Accurate SCS Model

- KCC scientists developed a **physics-based** modeling methodology (NWP), that captures all impacts of severe weather across the entire affected area



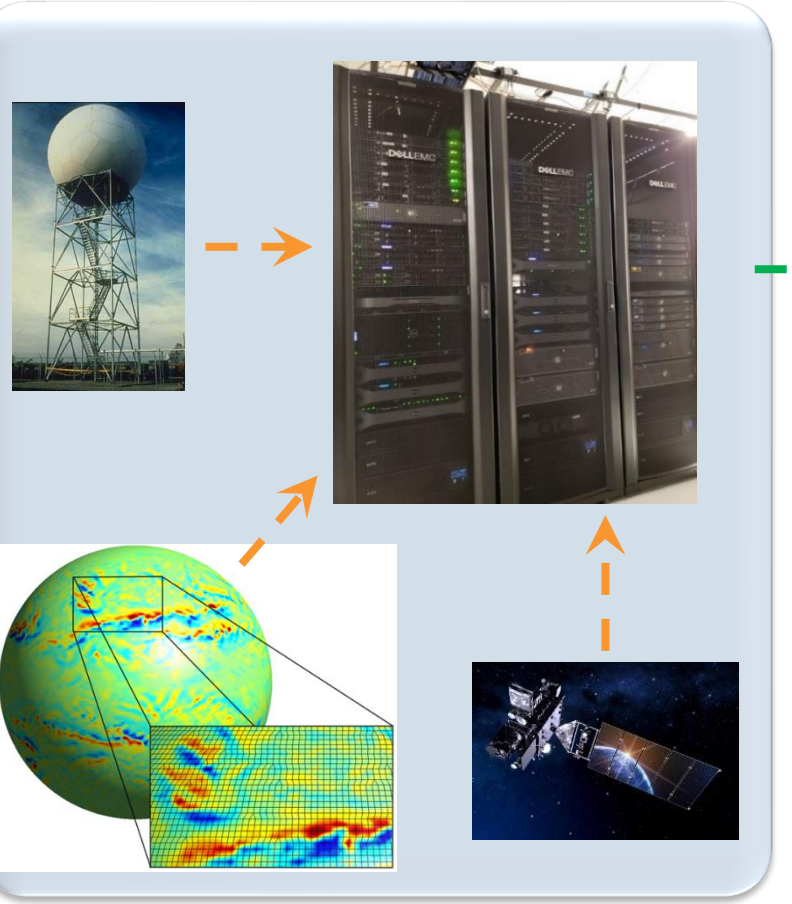
High resolution footprints capture all claims

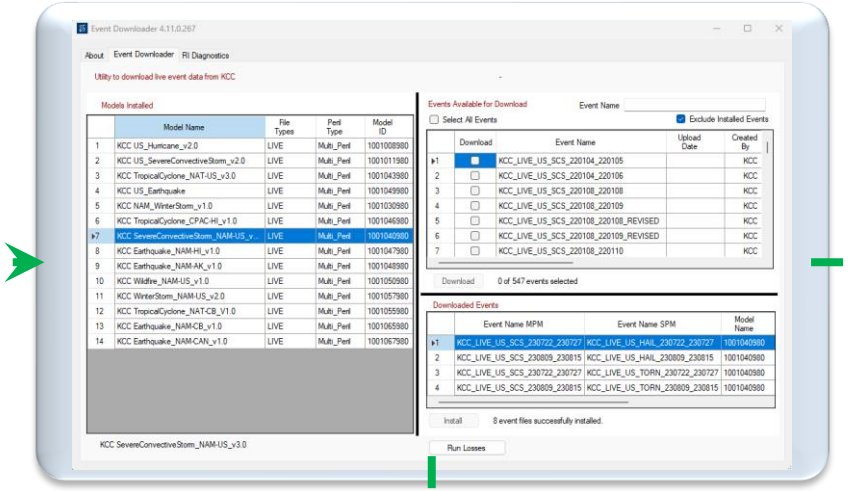


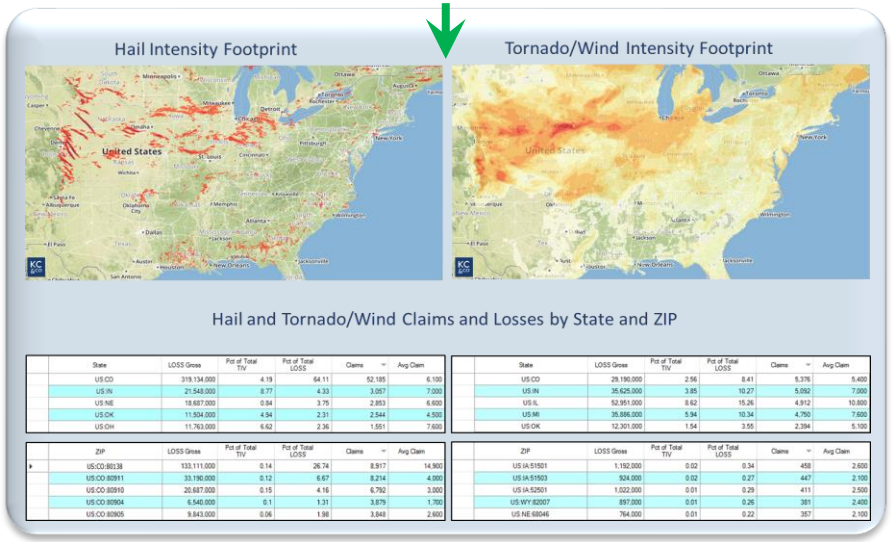


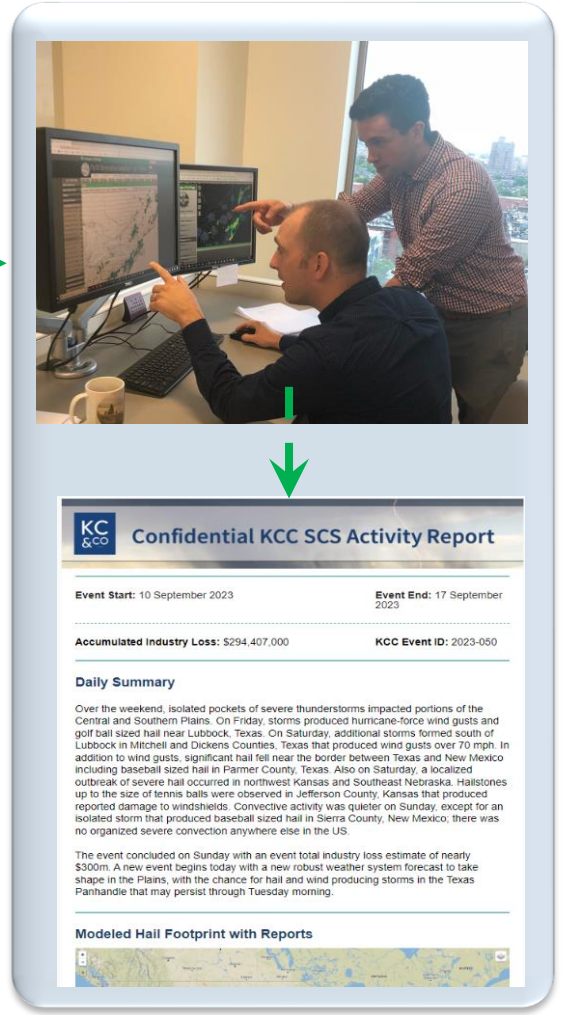
Advanced Science Combined with Continuous Model Verification: KCC LiveEvents

KCC models automatically ingest ~30 GB of data per day to support SCS LiveEvents

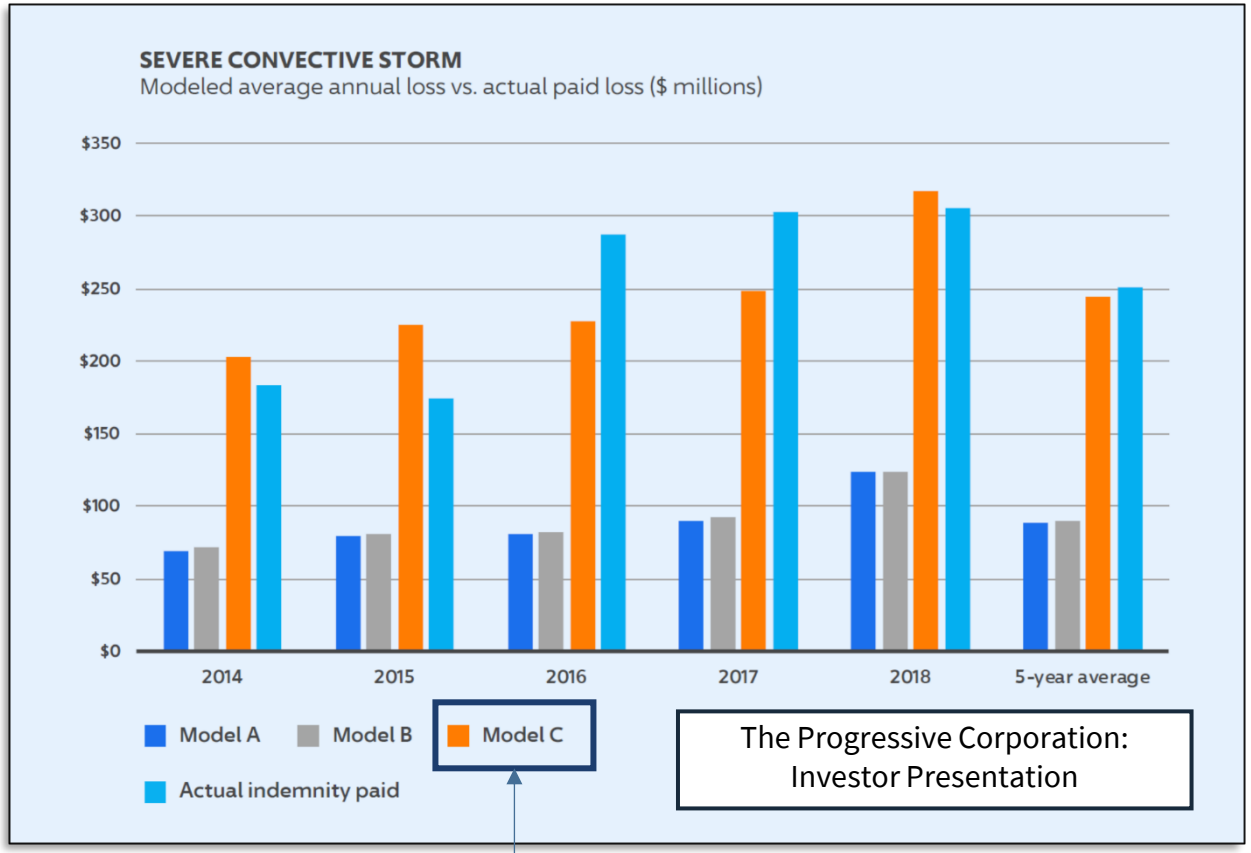


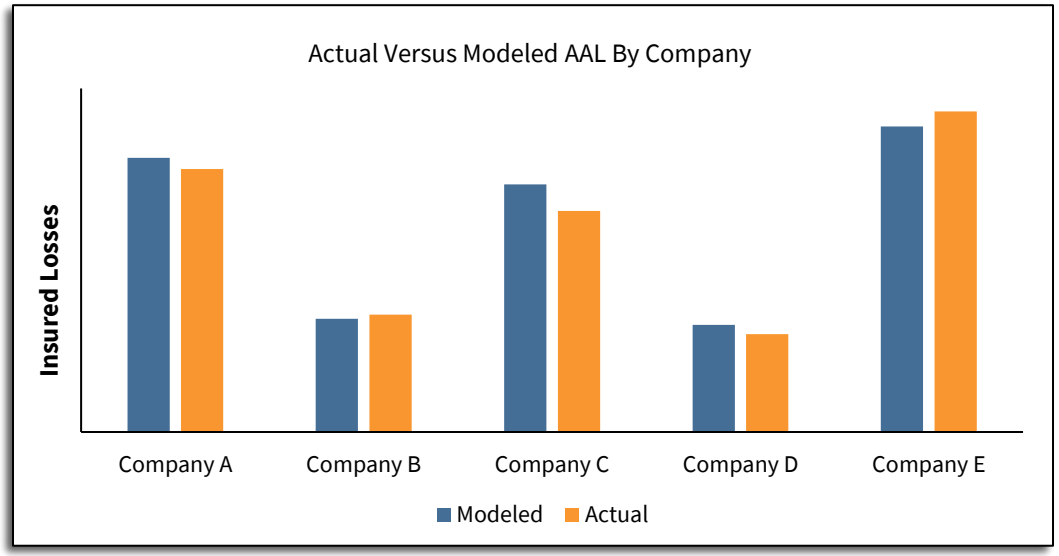


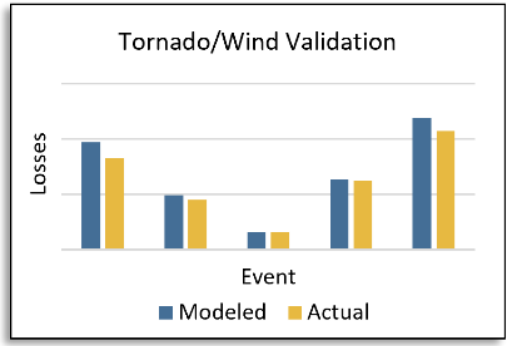


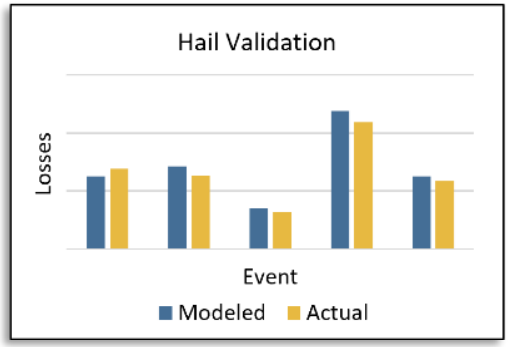


KCC SCS Model is Proven to Be Accurate: Insurer Validated Against $Billions Claims Data

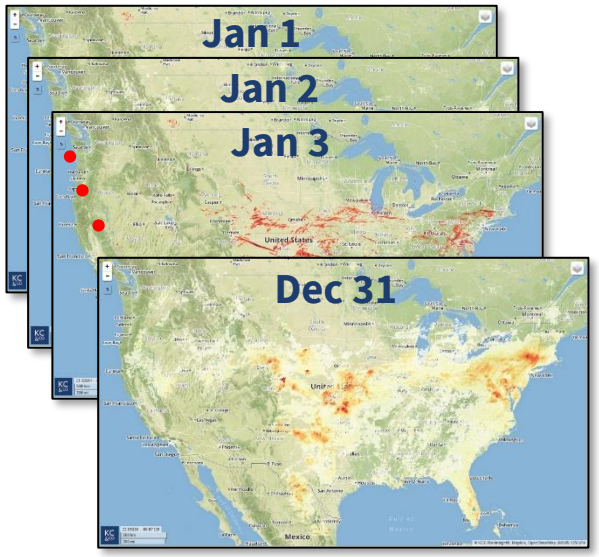








Accurate Models Can Expand Reinsurance Capacity: Modeled Loss Transactions



KCC Models Daily Footprint

Monthly Reporting Period	Aggregate Modeled Loss ($)	Cumulative Modeled Loss ($)
January	$7,825,595	$7,825,595
February	$11,200,561	$19,026,156
March	$27,816,254	$46,842,410
April	$38,999,243	$85,841,653
May	$52,032,565	$137,874,218
June	$75,425,003	$213,299,221
July	$79,160,293	$292,459,514
August	$59,528,400	$351,987,914
September	$45,390,582	$397,378,495
October	$32,886,477	$430,264,972
November	$24,540,235	$454,805,207
December	$11,054,600	$465,859,807

Monthly Loss Reports

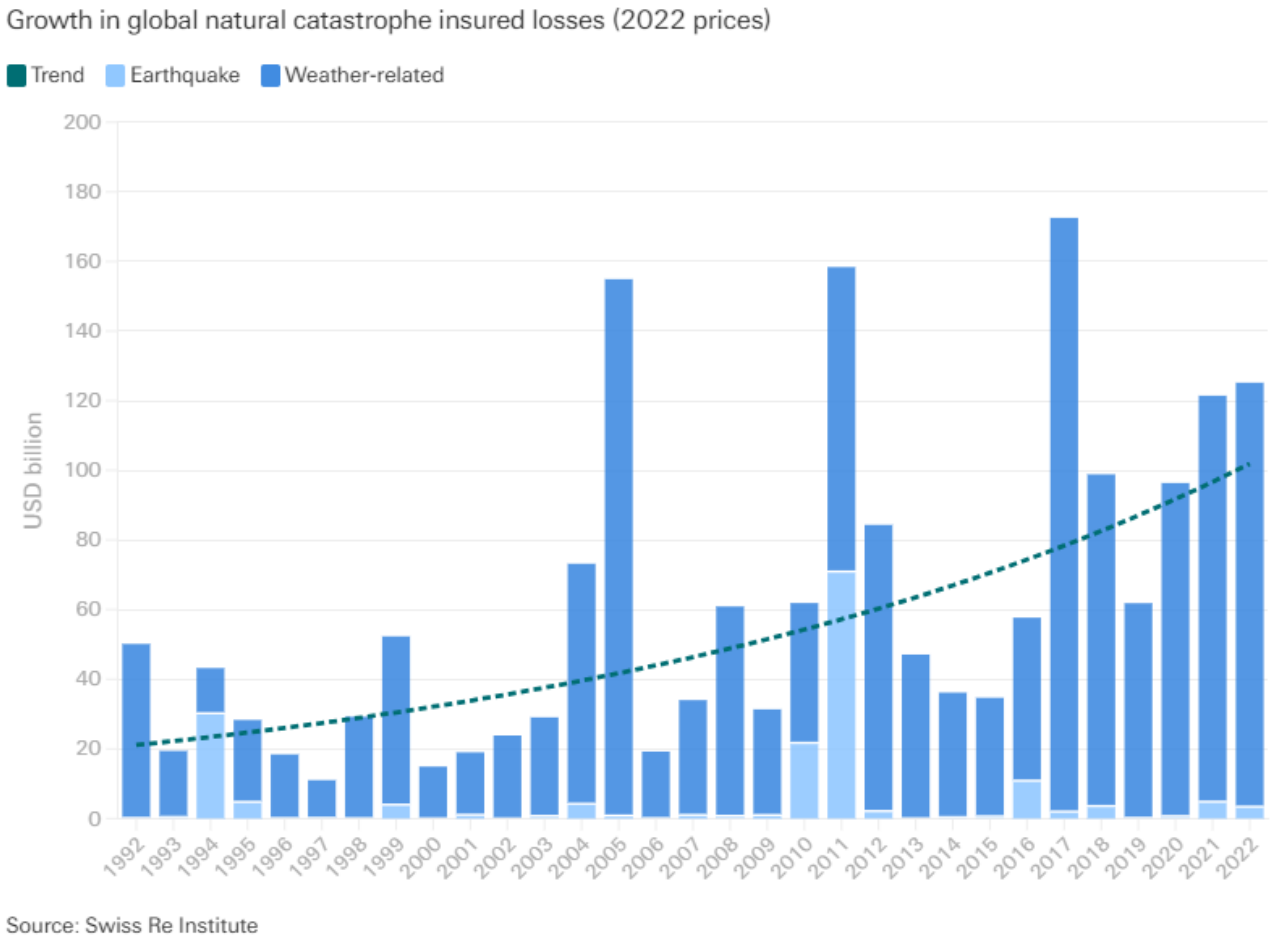
$400m Attachment Point

Payout Based on Modeled Loss

What's New: First SCS MLT Placed in 2023

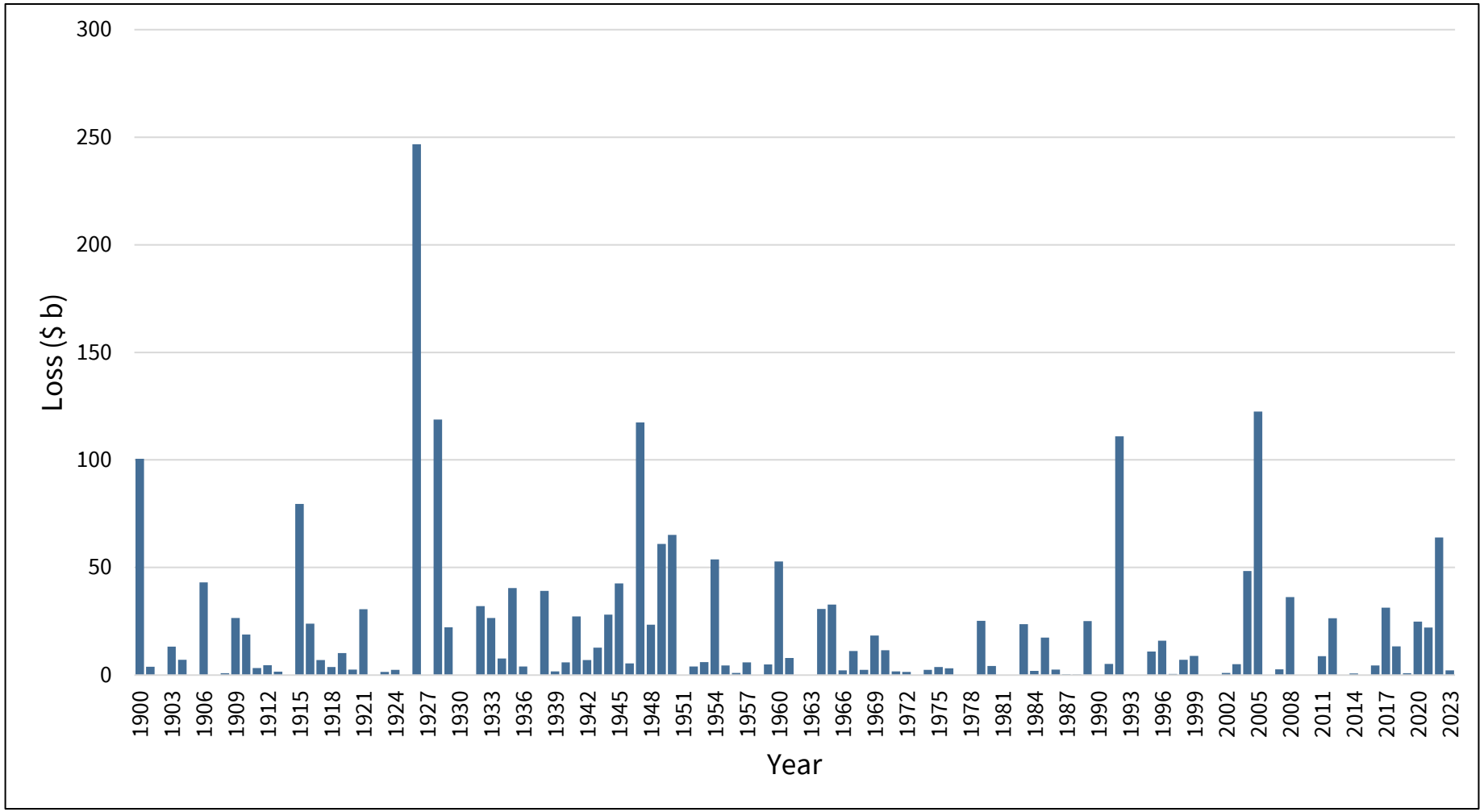
Multiple transactions to date on both an **occurrence** and **annual aggregate** basis

How Much of the Increases in Weather-Related Losses Are Due to Climate Change?



Source: Swiss Re Institute

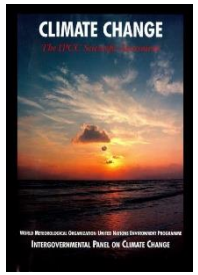
No Trend in Historical Hurricane Losses Based on Current Exposure*



* Incorporates population growth, demographic shifts, wealth effects, construction cost increases

The Intergovernmental Panel on Climate Change (IPCC) Assessment Reports Contain the Most Recent Scientific Consensus

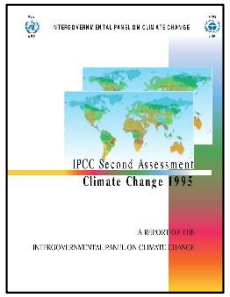
First Assessment Report (FAR)



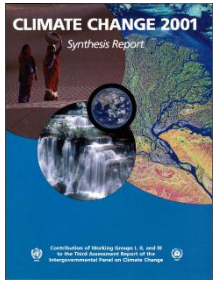
1990

1995

Second Assessment Report (SAR)



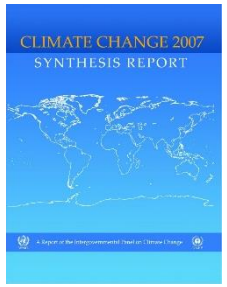
Third Assessment Report (TAR)



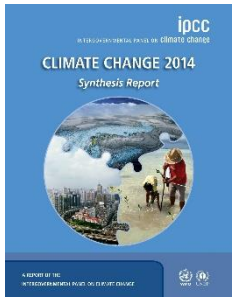
2001

2007

Fourth Assessment Report (AR4)

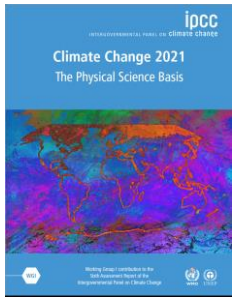


Fifth Assessment Report (AR5)



2014

2021



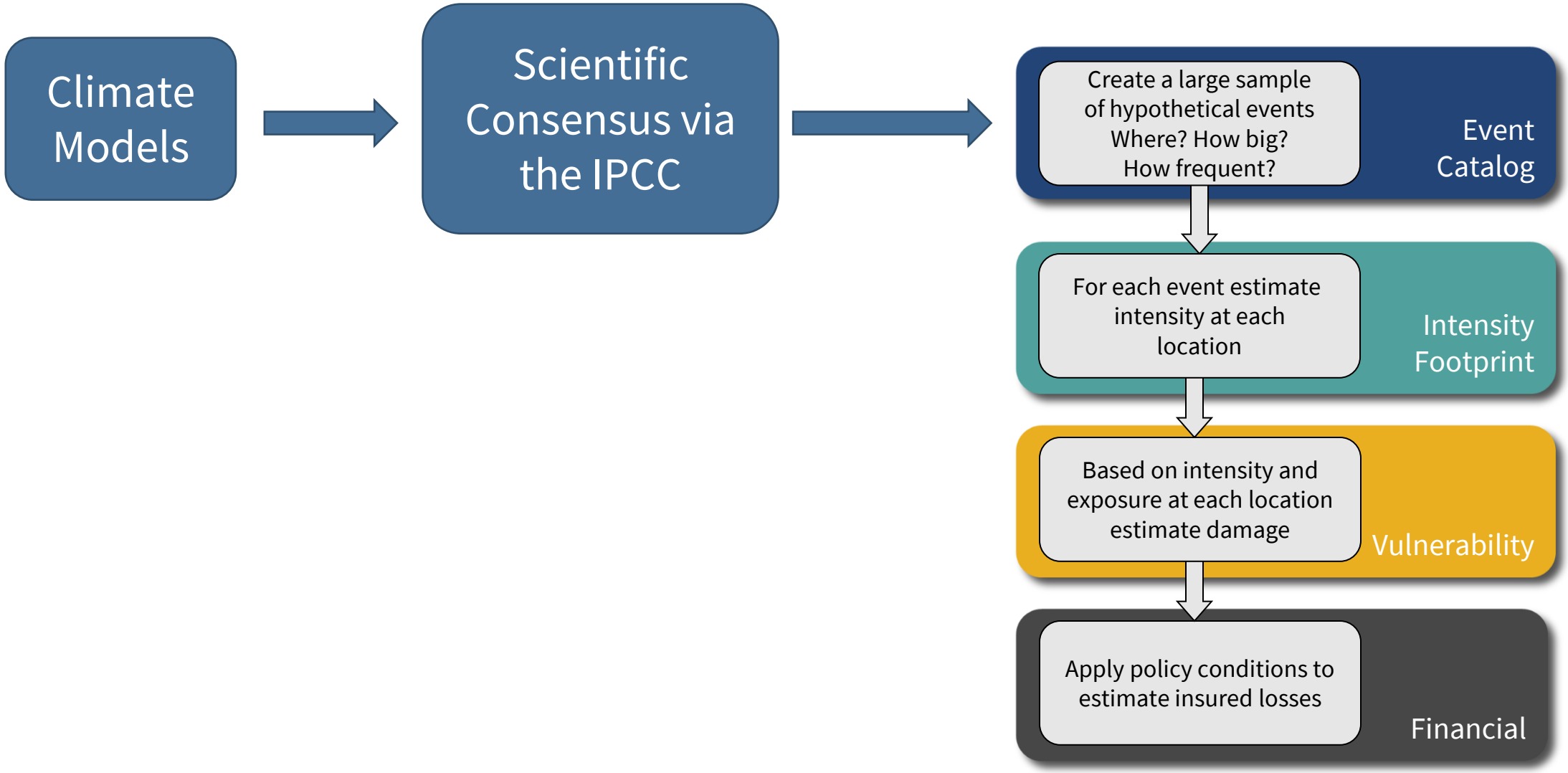
Sixth Assessment Report (AR6)

The AR6 Consensus on Climate Change Impacts on Weather and Extreme Events

	Frequency	Severity	Confidence
Hurricanes	No change	Increase	High
Coastal Flooding	Increase	Increase	High
Wildfires*	Increase	Increase	High
Inland Flooding*	Increase	Increase	Medium
Winter Storms	Uncertain	Increase	Medium
Severe Convective Storms	Uncertain	Uncertain	Low

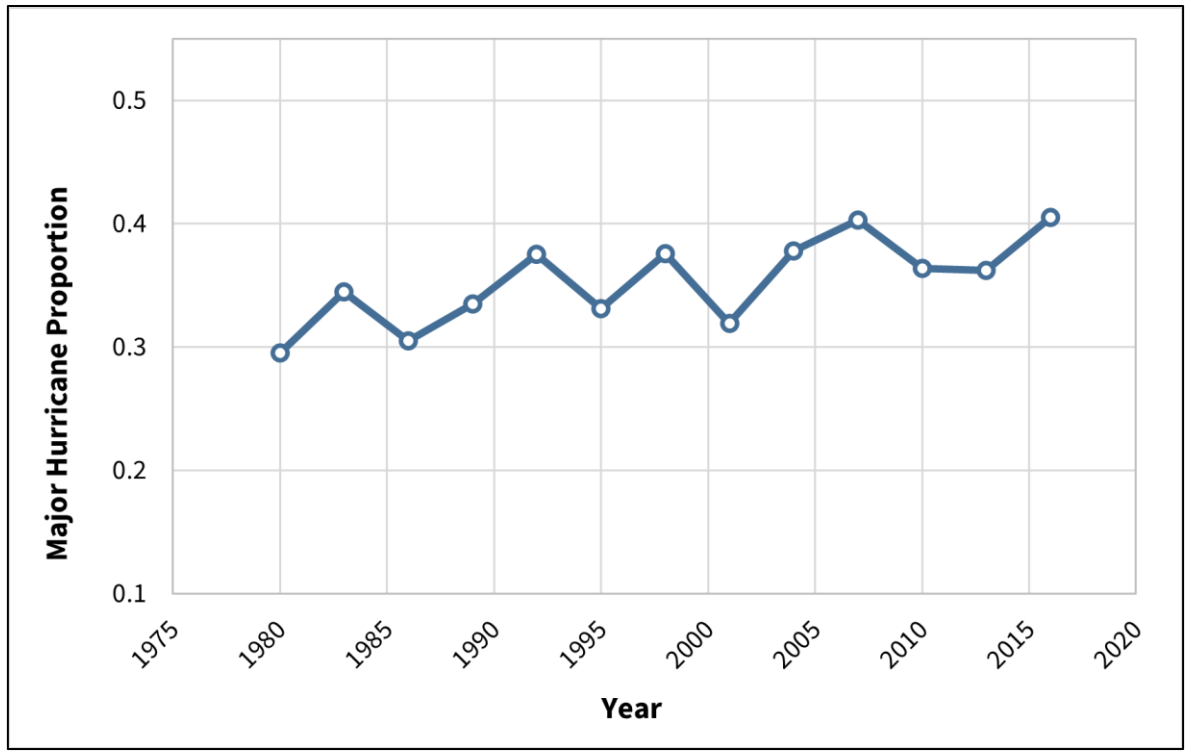
*Impacts of climate change are highly region-dependent

The Role of Climate Model Output in Catastrophe Modeling

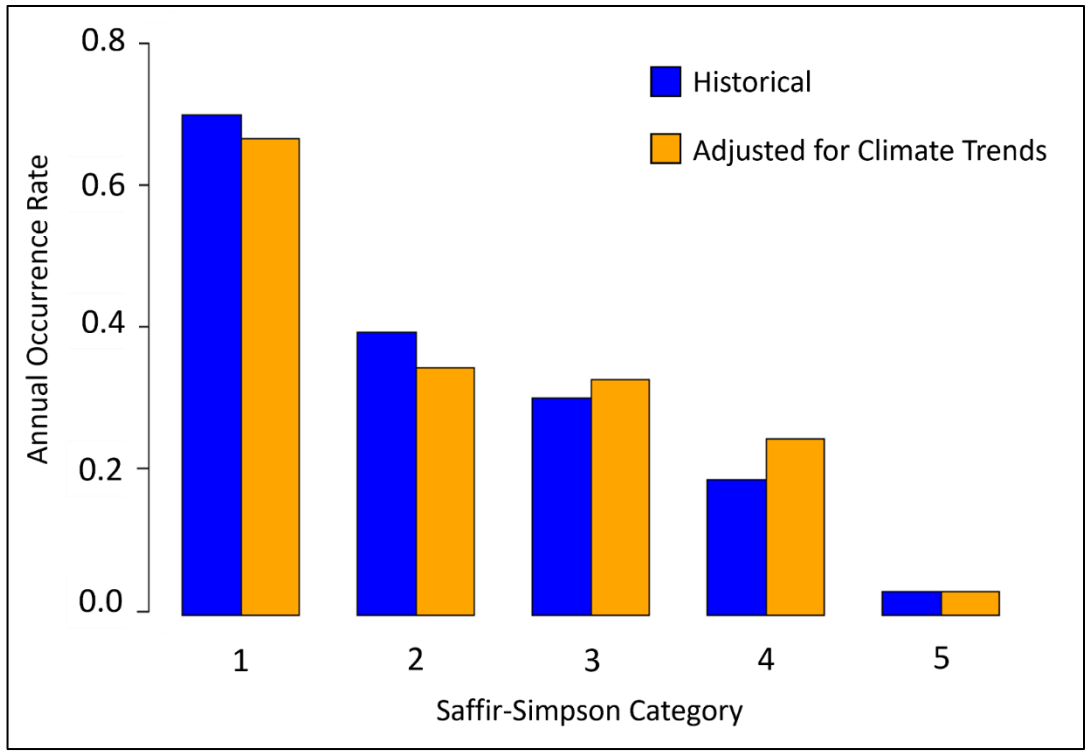


Scientific Consensus: the Proportion of Major Hurricanes is Increasing

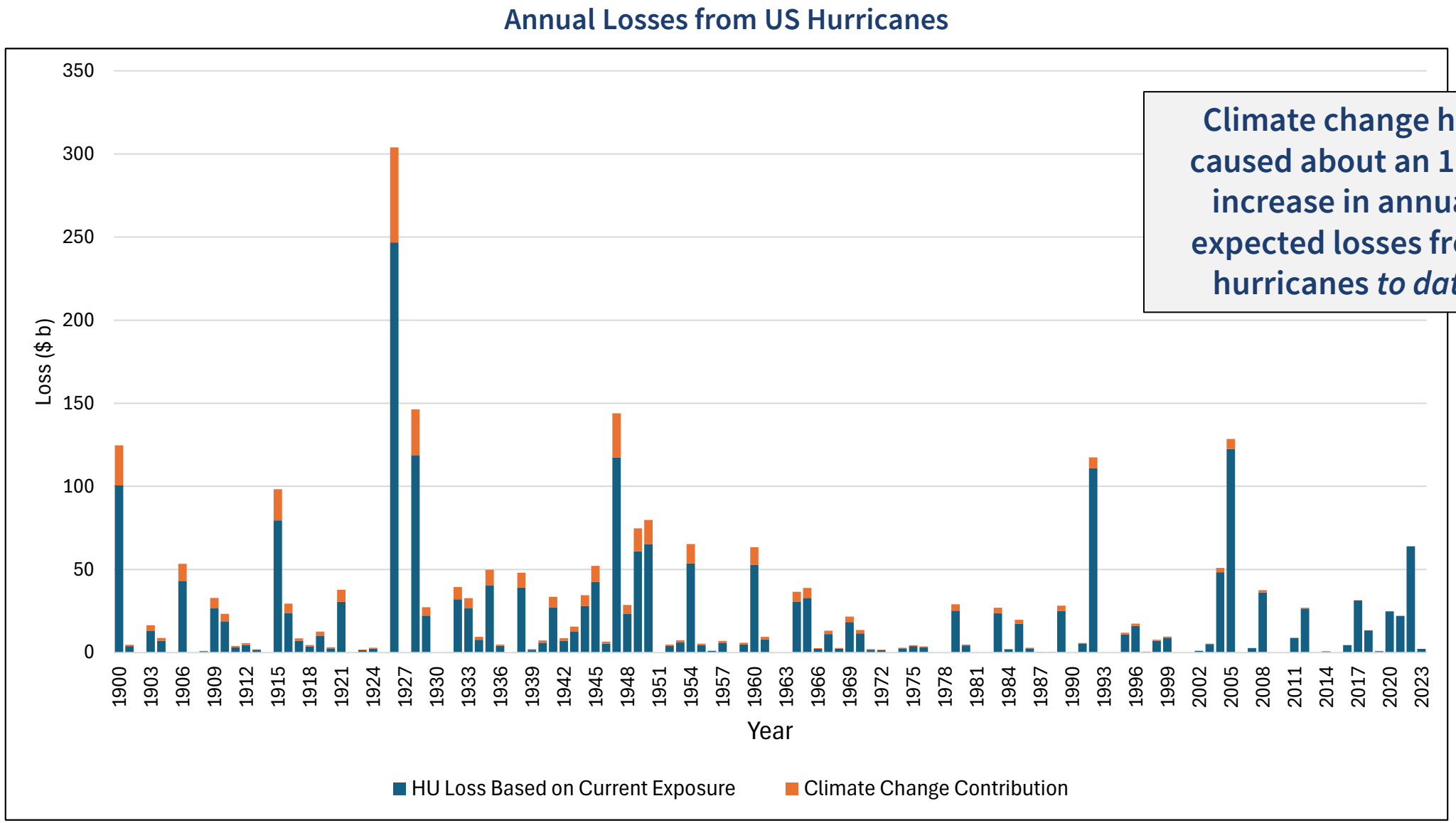
Observed Trend in Proportion of Category 3 to 5 Hurricanes



Shift Toward Major Hurricanes

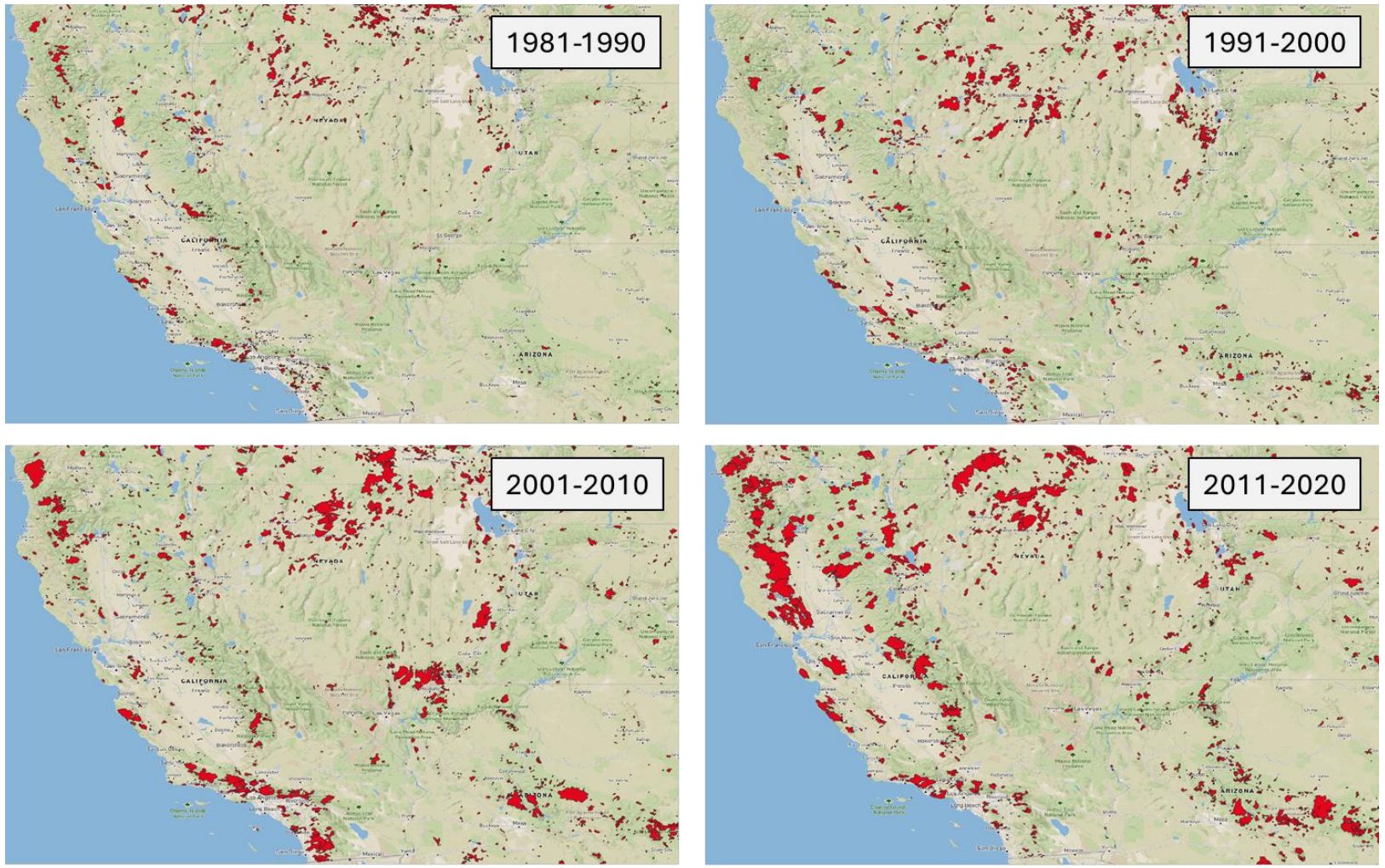


Contribution of Climate Change to Losses from Historical Hurricanes



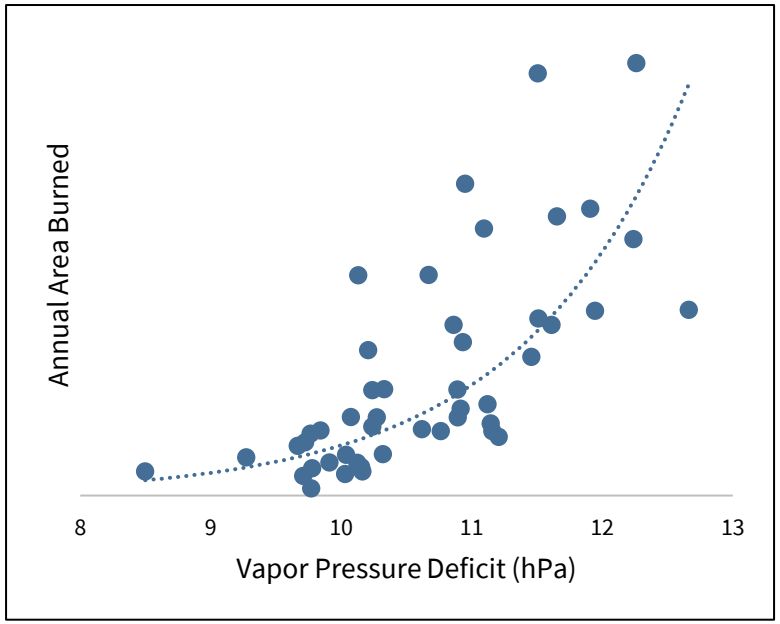
Climate change has caused about an 11% increase in annual expected losses from hurricanes *to date*

Climate Change is Having a More Significant Impact on Wildfire Activity

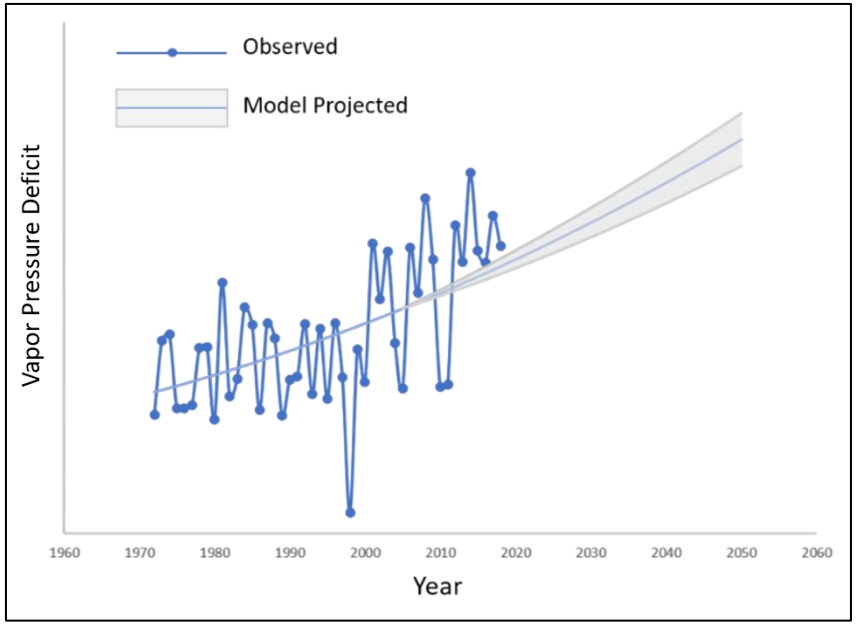


Climate-Conditioning the KCC Wildfire Model with Vapor Pressure Deficit (VPD)

Response of Fires to VPD Changes



Projected Increase in VPD

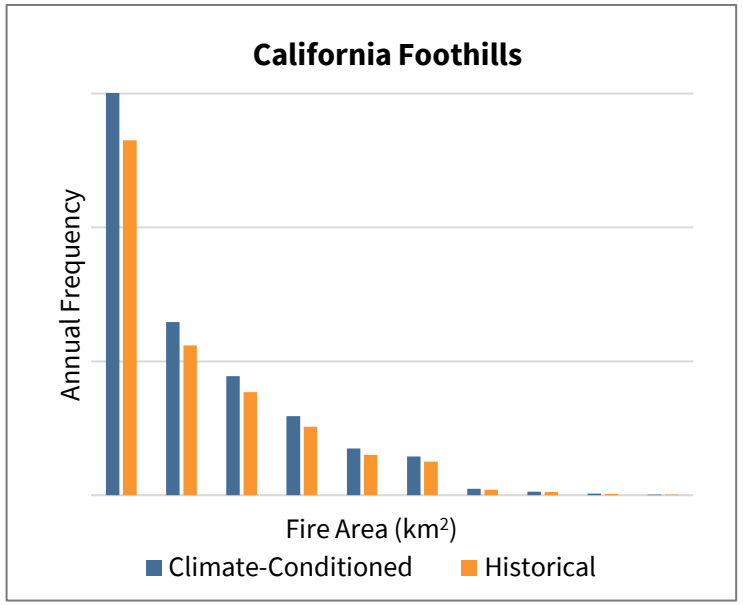


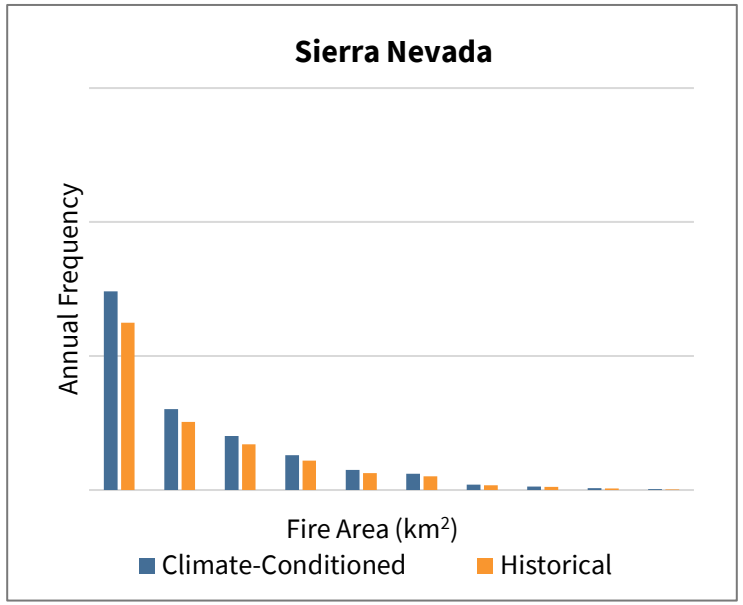
$$Saturation\ Vapor\ Pressure = 6.1078 * e^{[(17.269*T)/237.3+T]}$$

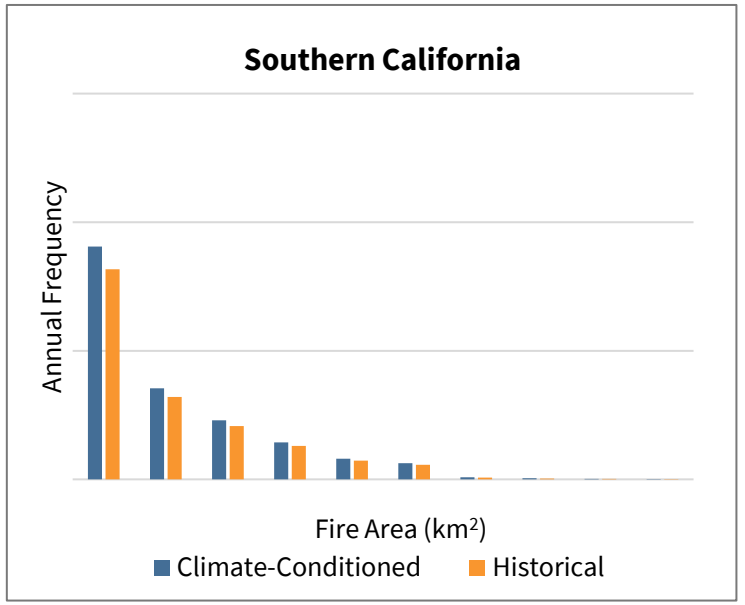
$$Vapor\ Pressure = 6.1078 * e^{[(17.269*T_d)/237.3+T_d]}$$

$$\boldsymbol{VPD} = Saturation\ Vapor\ Pressure - Vapor\ Pressure$$

Climate Change Conditioning Applied to All Fire Regions

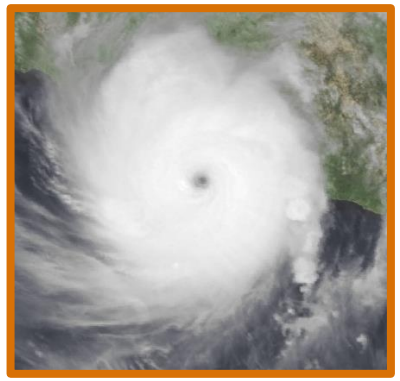






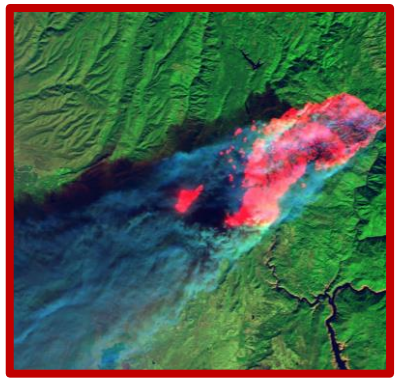
Why is it so Challenging to Quantify Climate Change Impacts on SCS?

Hurricane Intensity



Sea-Surface Temperatures

Wildfire Frequency



Vapor Pressure Deficit

Flood Frequency

Air Temperature

Severe Convective Storms

Lifted Index

Downdraft CAPE

CAPE

Level of Free Convection

CIN

SHEAR

Lifted Condensation Level

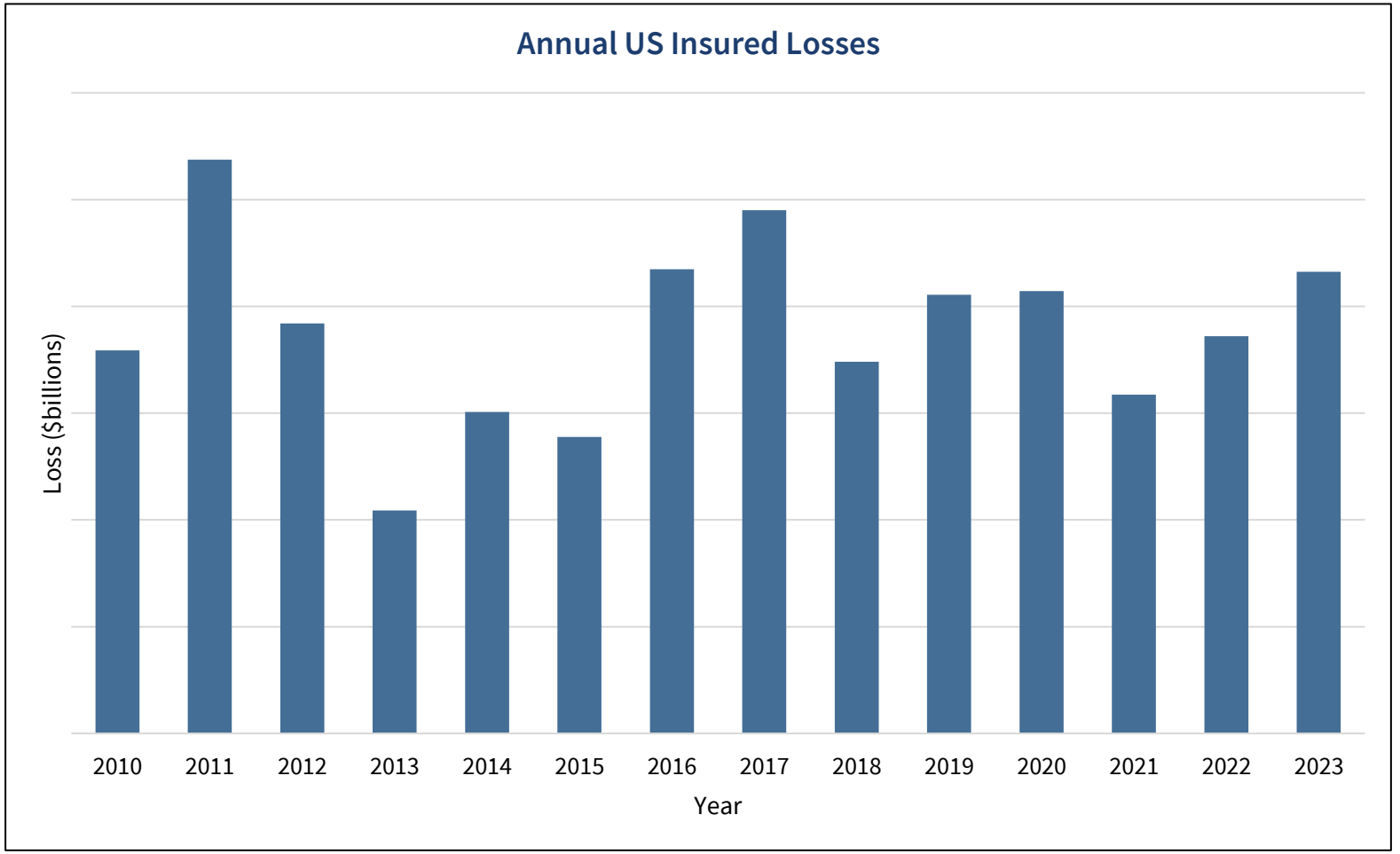
Low-Level Lapse Rate

Melting Level

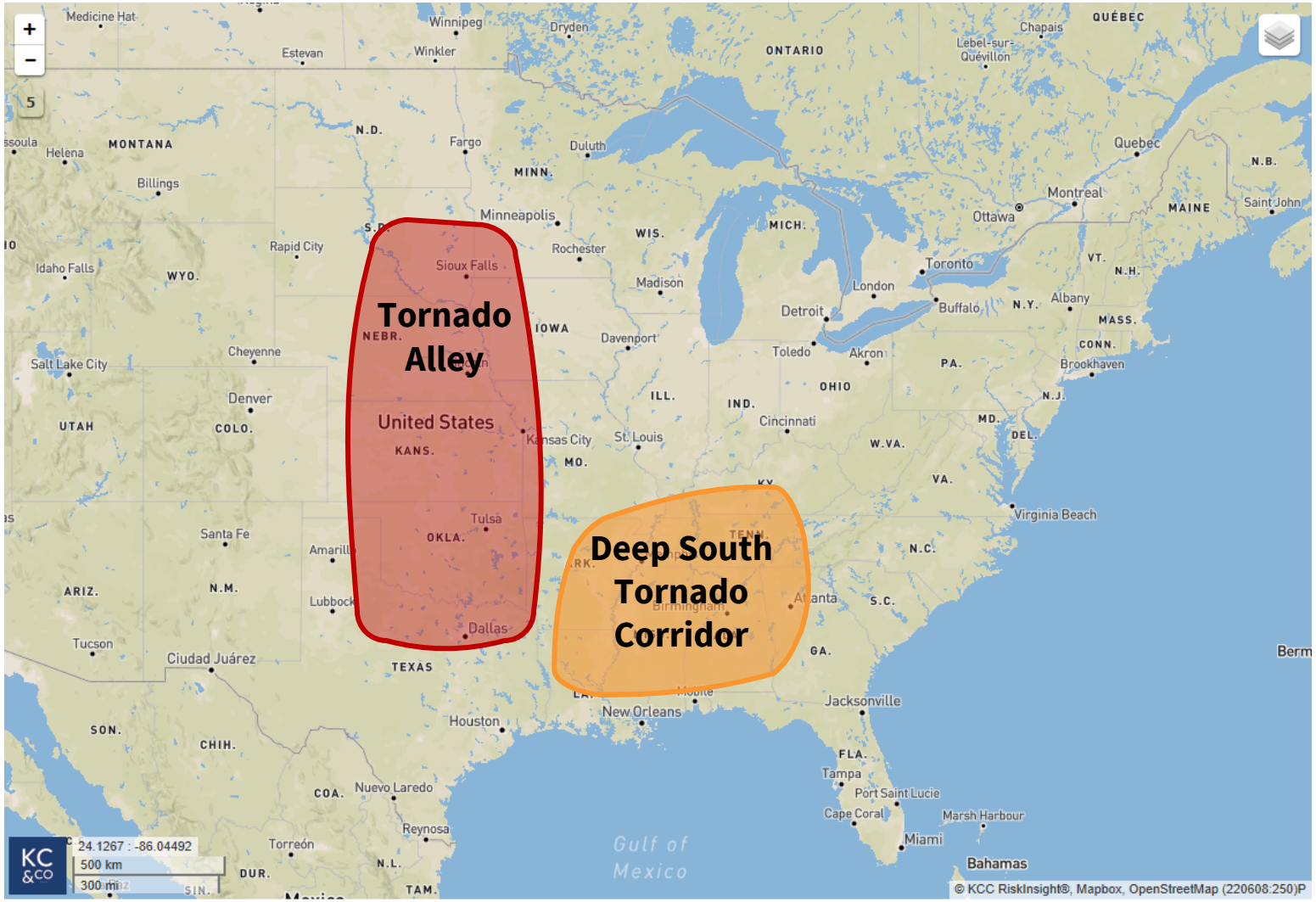
Helicity

Mid-Level Lapse Rate

No Trend in Annual Countrywide SCS Losses Calculated with Constant Exposure

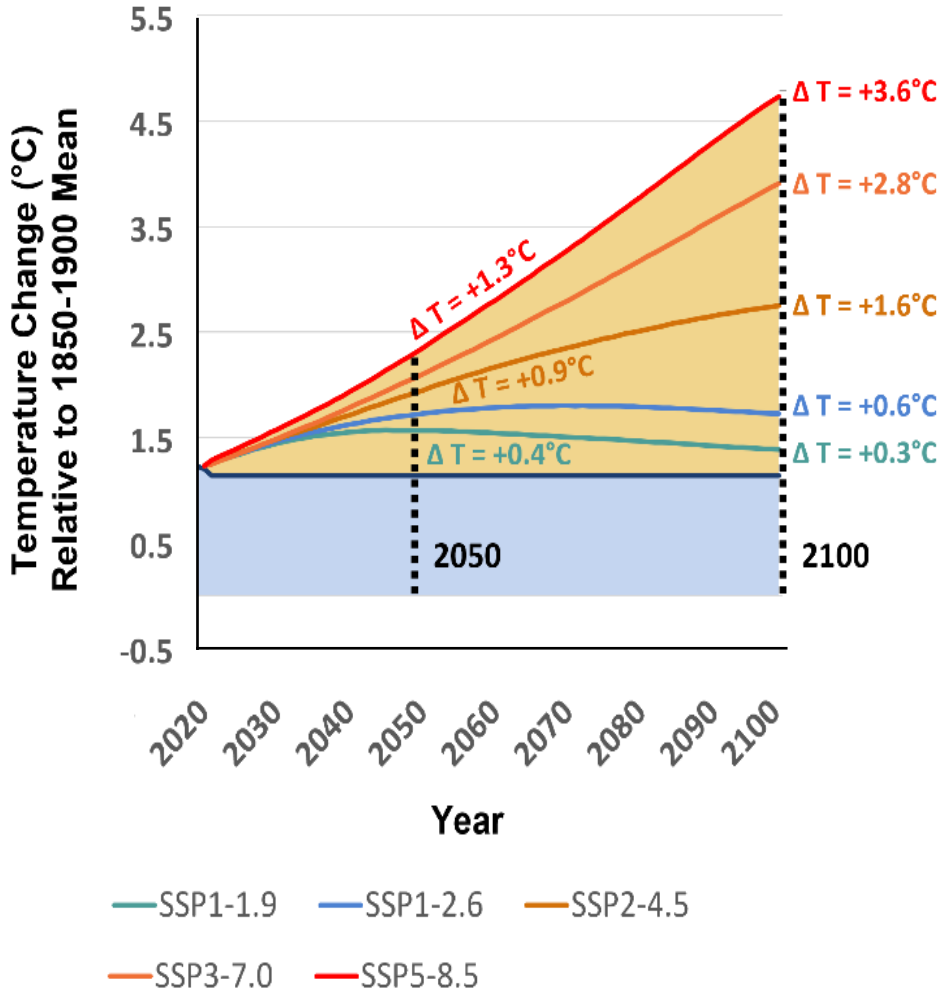


Evidence for a Shift in SCS Activity From Tornado Alley to the Southeast US



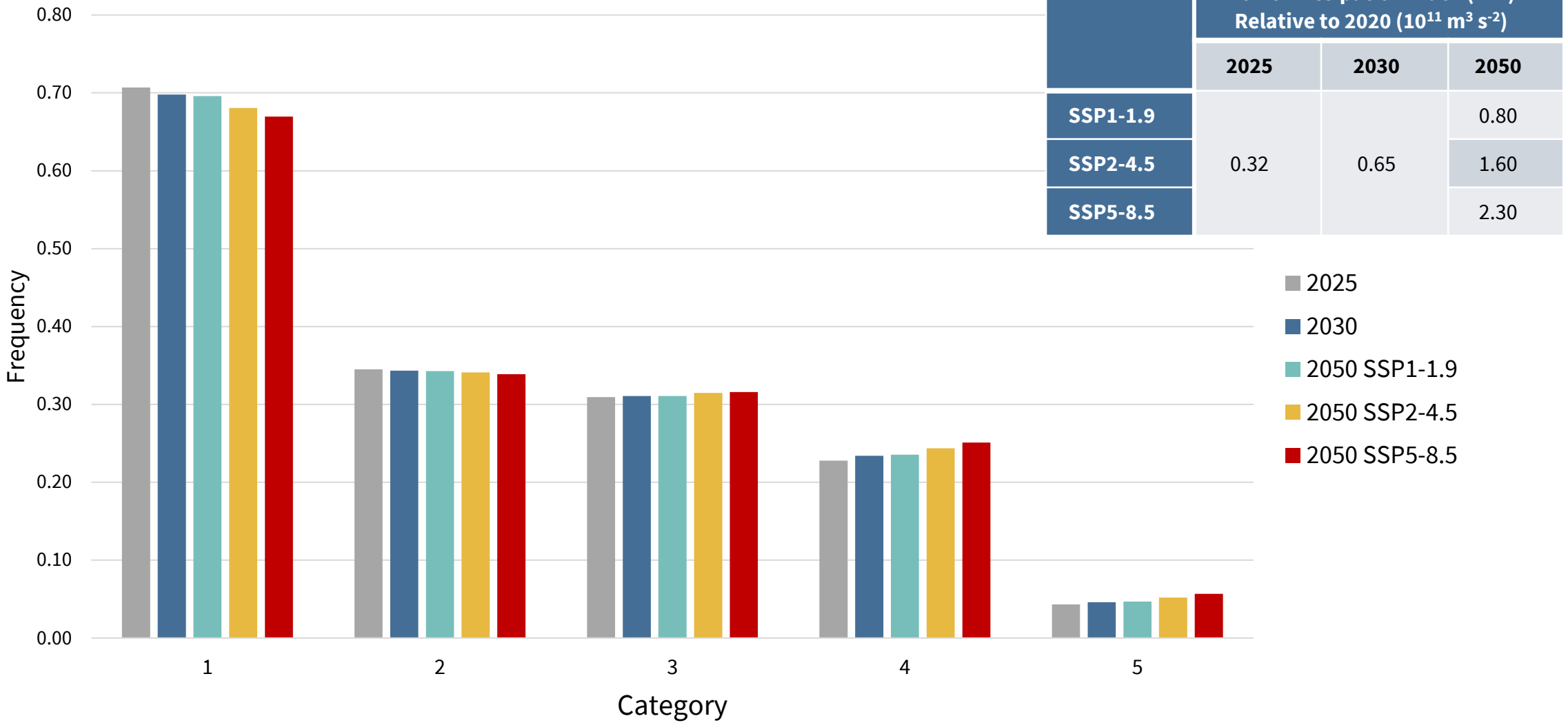
Future Increases Projected Using Shared Socioeconomic Pathways (SSPs)

Scenario	Radiative Forcing (W/m^2)	SSP Assumptions
SSP1-1.9	1.9	Global shift toward environmentally sustainable economic growth. Significantly and rapidly reduced per capita energy consumption, reaching net zero emissions by 2050.
SSP1-2.6	2.6	Global shift to sustainability and emissions cut significantly to net zero by 2050, but at a slower rate than SSP1-1.9 leading to a larger radiative forcing.
SSP2-4.5	4.5	Largely business-as-usual with regard to technological advancements and economic growth, with slow progress toward sustainability goals.
SSP3-7.0	7.0	Increased global competition and a shift towards national security and resource stockpiling, leading to significant increase in emissions from modern level.
SSP5-8.5	8.5	Rapid global economic growth supported by heavy investment in fossil fuel energy.

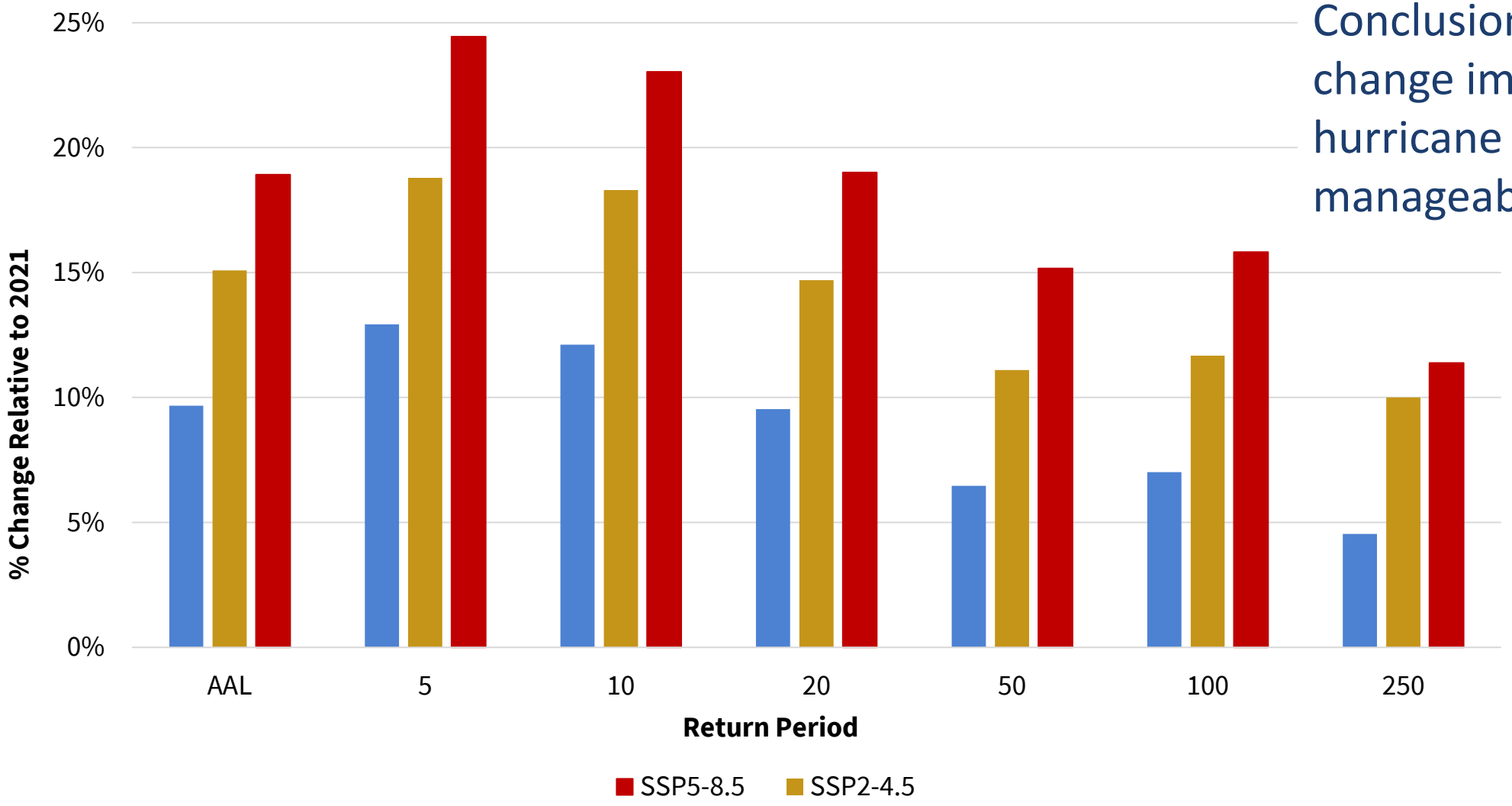


Projected Increases in Atlantic Hurricane Intensity for Future Scenarios

	Power Dissipation Index (PDI) Relative to 2020 (10^{11} m^3 s^{-2})		
	2025	2030	2050
SSP1-1.9	0.32	0.65	0.80
SSP2-4.5			1.60
SSP5-8.5			2.30

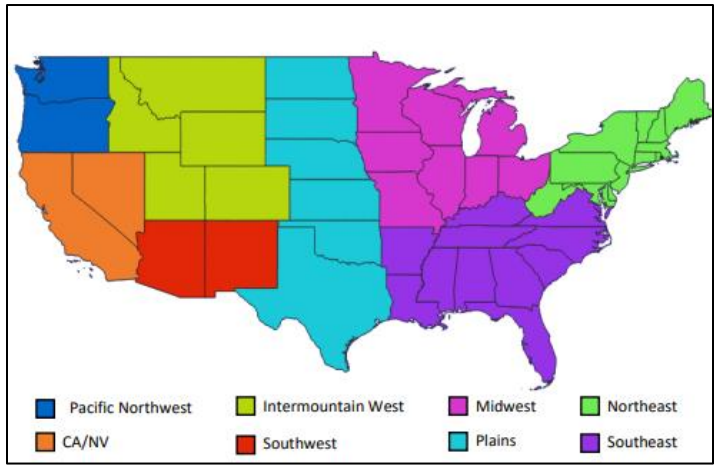


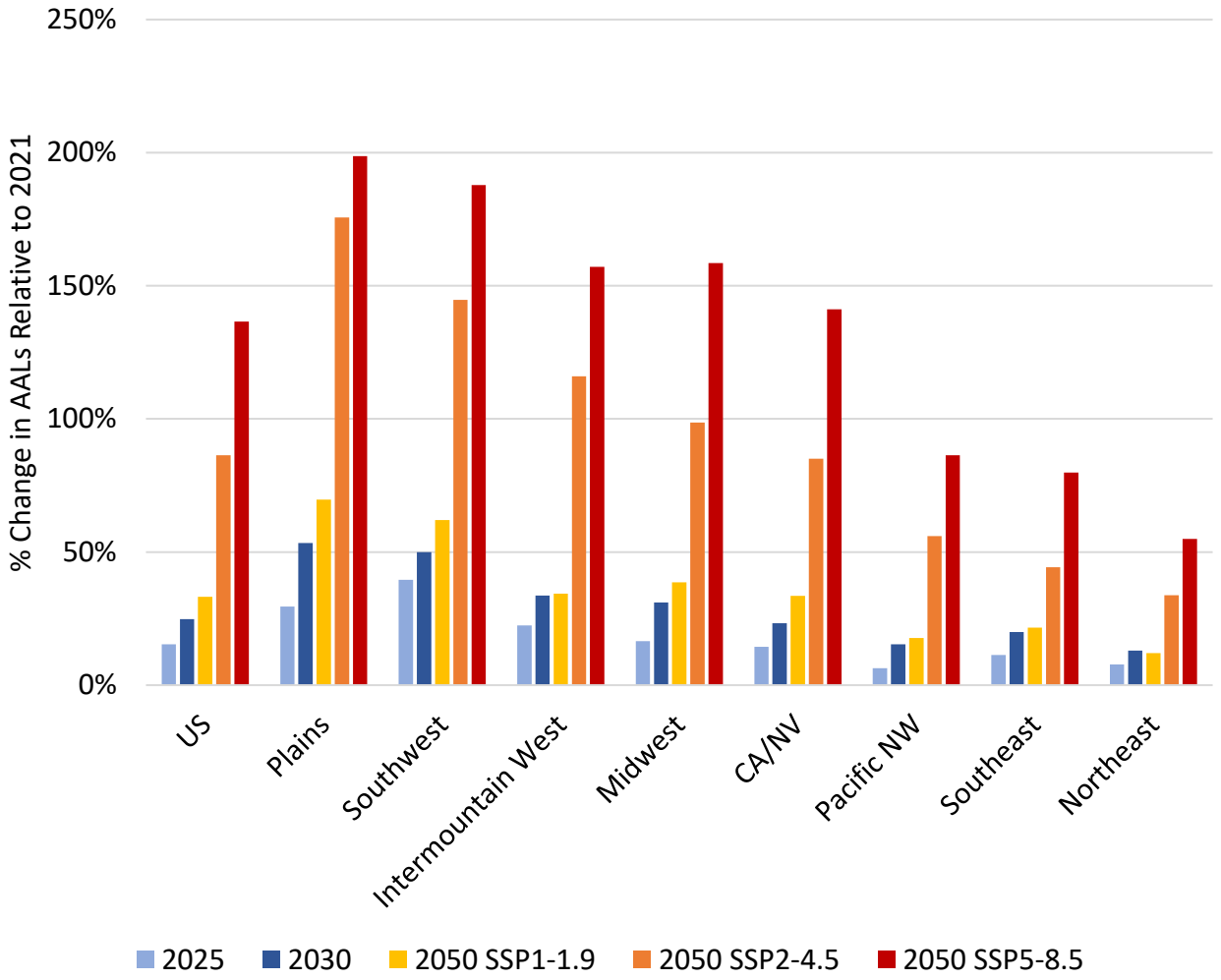
Insured Loss Increases by 2050: Increases Generally Less Than 1 Percent Per Year



Conclusion: Climate change impacts on hurricane losses are manageable

KCC Future Climate Catalogs Show the Regional Impacts of Climate Change on Wildfire Losses





Summary

Thank you

Questions?

