Climate Change and Risk Management

Extending the Time Horizon

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The Future is Uncertain and Full of Terrors

Why Should Actuaries Study Climate Change?

We manage risk.

The future is uncertain and full of risk. Risk is the chance that an undesirable event will occur, but risk is also opportunity. That's where we come in.

Actuaries are experts in:

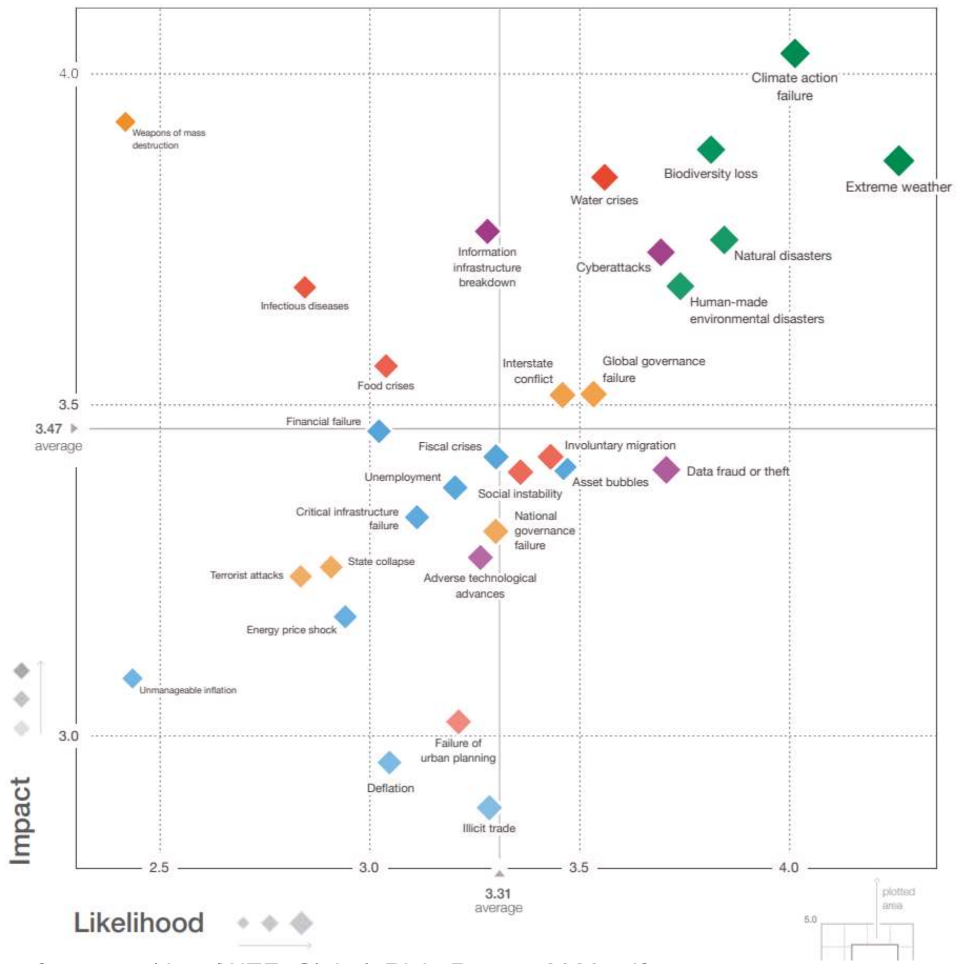
- Evaluating the likelihood of future events—using numbers, not crystal balls.
- Designing creative ways to reduce the likelihood of undesirable events.
- Decreasing the impact of undesirable events that do occur.

We are the leading professionals in finding ways to manage risk. It takes a combination of strong analytical skills, business knowledge, and understanding of human behavior to manage today's complex risks facing our society.

Source: https://www.beanactuary.org/ "what we do"

Why Should Actuaries Study Climate Change?

- Climate-related challenges are now seen by many as the most significant global risk.



Source: World Economic Forum, Global Risks Report http://www3.weforum.org/docs/WEF_Global_Risk_Report_2020.pdf

Why Should Actuaries Study Climate Change?

- Widespread awareness of the significance of the issue is a recent phenomenon.

Economic
Asset bubble
Critical infrastructure failure
Deflation
Energy price shock
Financial failure
Fiscal crises
Illicit trade
Unemployment
Unmanageable inflation

Environmental
Biodiversity loss
Climate action failure
Extreme weather
Human-made environmental disaster
Natural disasters

Geopolitical
Global governance failure
Interstate conflict
National governance failure
State collapse
Terrorist attacks
Weapons of mass destruction

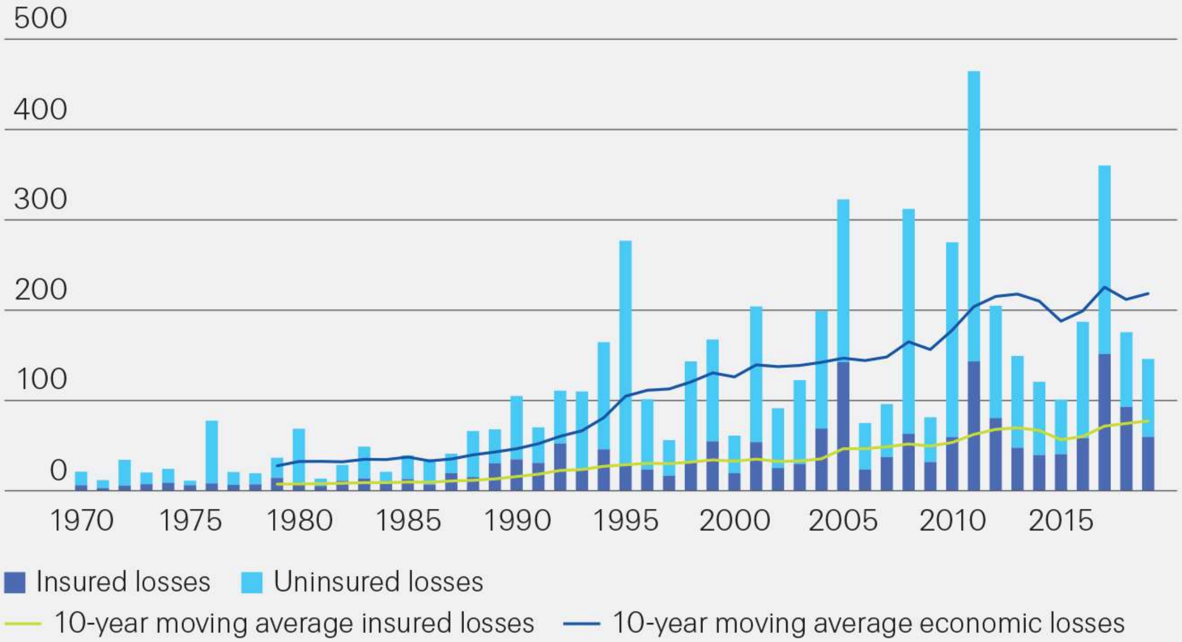
Societal
Failure of urban planning
Food crises
Infectious diseases
Involuntary migration
Social instability
Water crises

Technological
Adverse technological advances
Cyberattacks
Data fraud or theft
Information infrastructure breakdown

Source: World Economic Forum, Global Risks Report
http://www3.weforum.org/docs/WEF_Global_Risk_Report_2020.pdf

Much of the Emerging Risk is Uninsured

Insured vs uninsured losses, 1970–2019 (USD billion, 2019 prices)



Economic losses = insured + uninsured losses;
Source: Swiss Re Institute

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Is climate risk insurable?

Large number of similar exposure units:
Since insurance operates through pooling resources, the majority of insurance policies are provided for individual members of large classes, allowing insurers to benefit from the law of large numbers in which predicted losses are similar to the actual losses.

Definite Loss:
The loss takes place at a known time, in a known place, and from a known cause.

Accidental Loss:
The event that constitutes the trigger of a claim should be fortuitous, or at least outside the control of the beneficiary of the insurance.

Large Loss:
The size of the loss must be meaningful from the perspective of the insured.

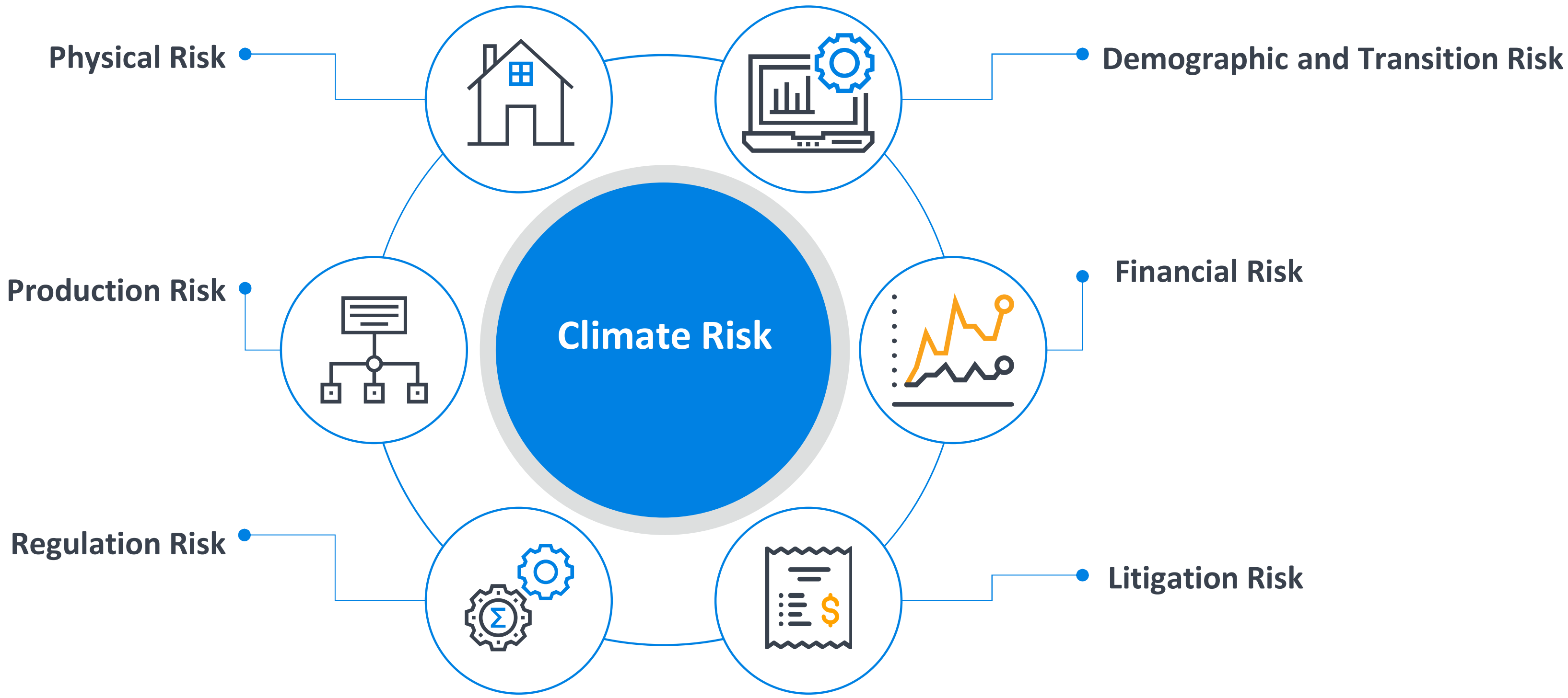
Affordable Premium: If the likelihood of an insured event is so high, or the cost of the event so large, that the resulting premium is large relative to the amount of protection offered, it is not likely that anyone will buy insurance, even if on offer.

Calculable Loss: There are two elements that must be at least estimable, if not formally calculable: the probability of loss, and the attendant cost.

Limited risk of catastrophically large losses: Insurable losses are ideally independent and non-catastrophic, meaning that losses do not happen all at once and individual losses are not severe enough to bankrupt the insurer.

Source: https://en.wikipedia.org/wiki/Insurability

Climate Risk Presents an Array of Vulnerabilities



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Why Should Actuaries Study Climate Change?

Climatic Impacts		Socio-Economic Impacts		Impacts on Actuarial Work
Direct	Indirect	Social	Economic	
• Heatwaves • Storms • Floods • Sea level rise • Bush fires • Droughts	• Air pollution • Water and food supply • Diseases	• Migration • Health infrastructure • Emergency and social services • Consumer behavior	• GDP growth • Investor preferences • Infrastructure investment • Employment • Housing • Energy • Taxation	• Changes to modelling and assumptions • Development of products including re-design, pricing, exclusions, etc. • Changes to risk management practices • Changes to capital management practices • Prevised/new investment management practices • Changes to financial stability management • Disclosure that allows for climate risk • Broader application of actuarial work

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Source: International Association of Actuaries, Importance of Climate Related Risks for Actuaries
https://www.actuaries.org/IAA/Documents/Publications/Papers/CRTF_ImportanceClimateRelatedRisksActuaries_FINAL.pdf

Actuarial Organizations are Making Climate a Top Priority

CASUALTY ACTUARIAL SOCIETY (CAS)

The primary purpose of the Climate Change Committee (created in November 2008) is to recommend, support and perform research on climate change and assess the potential risk management implications for the insurance industry. T

AMERICAN ACADEMY OF ACTUARIES (THE ACADEMY)

The Academy conducts climate activities through its Property/Casualty Extreme Events Committee. Successive editions of its magazine, *Contingencies*, feature articles on climate-related issues, including a cover story on rising sea levels.

CANADIAN INSTITUTE OF ACTUARIES (CIA)

The Climate Change & Sustainability Committee (CCSC) dates from April 2014. Presentations on climate issues are made by the committee at each annual meeting as well as periodic CIA Board meetings.

Source: The Actuary Magazine
https://theactuarymagazine.org/the-challenges-of-climate-change/

Thank you

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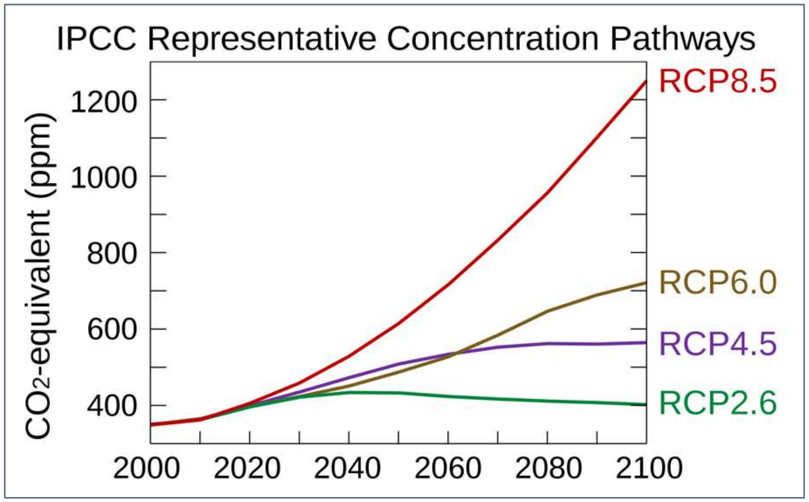
CAS Annual Meeting

Climate Change and Risk Management - Extending the Time Horizon

11/12/2020

Climate Change Scenarios (IPCC)

- The Intergovernmental Panel on Climate Change (IPCC) is the international authority on climate science and climate change scenarios. Future scenarios are typically described as Representative Concentration Pathways (RCP).
  - RCP scenarios define the concentration of greenhouse gas emissions given different international mitigation strategies (or lack thereof)
  - Increases in greenhouse gasses are known to increase mean average global temperatures which has downstream effects on meteorological peril magnitude and frequency
    - Hurricanes
    - Inland flooding
    - Wildfire
    - Severe convective storm
    - Etc.



Climate Change by the Numbers

- Hurricanes (US)
  - Impact of sea level rise on storm surge losses in the US
    - KatRisk: sea level rise will cost about $20 million per year (~0.4% increase p.a.)
  - Impact of higher temperature on tropical cyclone precipitation
    - Literature: increase of 1 degree Celsius of SST leads to significant increase
    - Amount of increase varies in recent papers, need more studies
  - Impact of the slowdown of tropical cyclones
    - Would lead to increases in precipitation

*

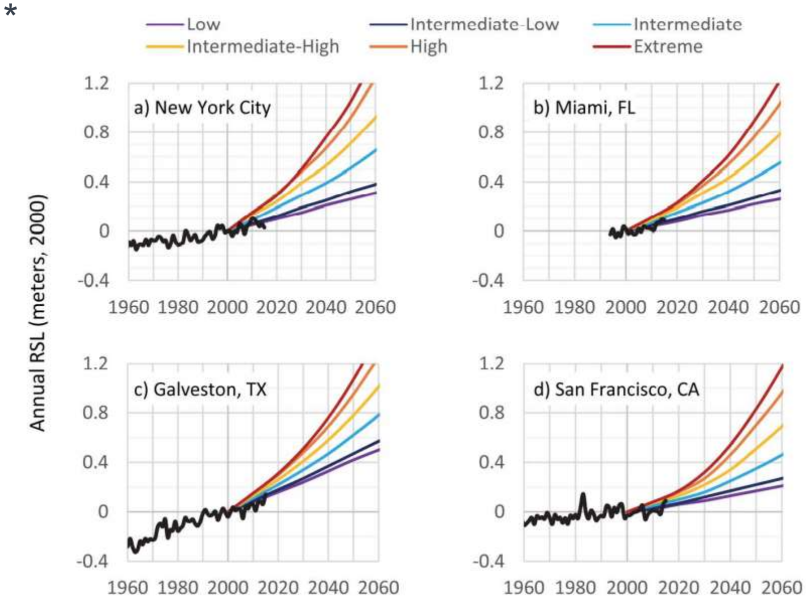


Figure 14. Average annual RSL for New York City (The Battery), Miami (Virginia Key), Fla., Galveston, Tex. and San Francisco, Calif. with their respective (median-value) RSL under the six scenarios. The NOAA RSL observations (tidesandcurrents.noaa.gov/sltrends) are shown relative to the midpoint (year 2000) of the 1991–2009 epoch (1994–2009 at Virginia Key), which is the reference level for the scenarios.

*National Oceanic and Atmospheric Administration (January 2017). Global and Regional Sea Level Rise Scenarios for the United States. Available at: https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

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CAS Question

Climate Induced global sea level rise in the US has the most effect on

a) Coastal Florida
b) Coastal New York
c) Coastal Texas
d) Coastal North Carolina

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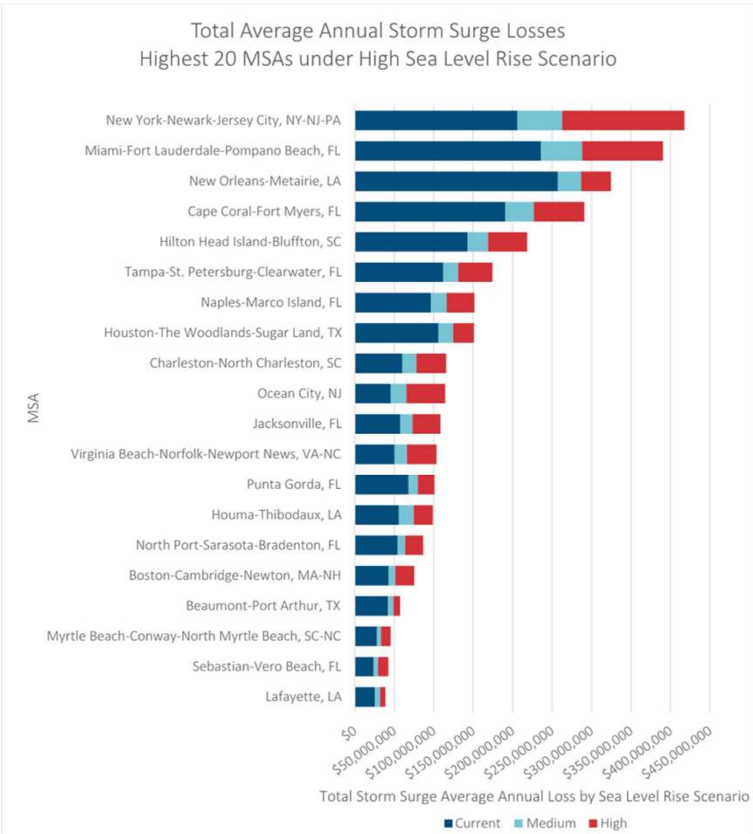
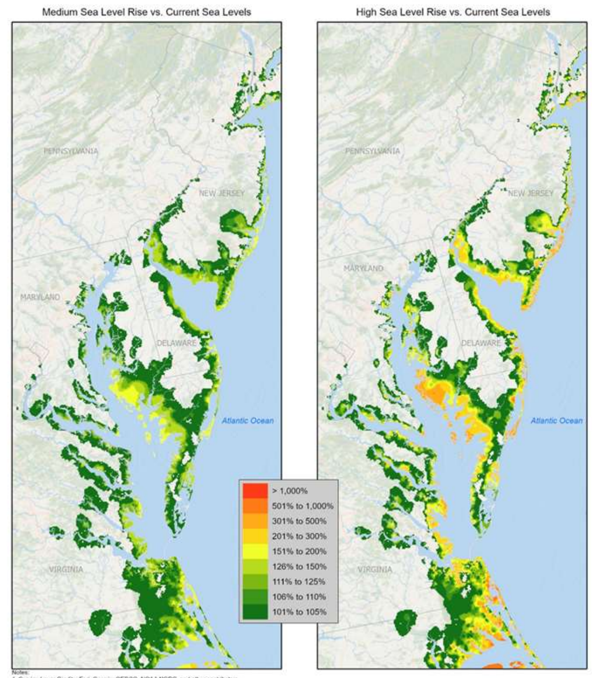
Climate Change by the Numbers





https://www.soa.org/resources/research-reports/2020/soa-flood-report/

CAS Question

Climate change will do the following to precipitation in the US

a) Increase annual total precipitation everywhere
b) Decrease annual total precipitation everywhere
c) Increase annual total precipitation in some places, and decreased it in other places

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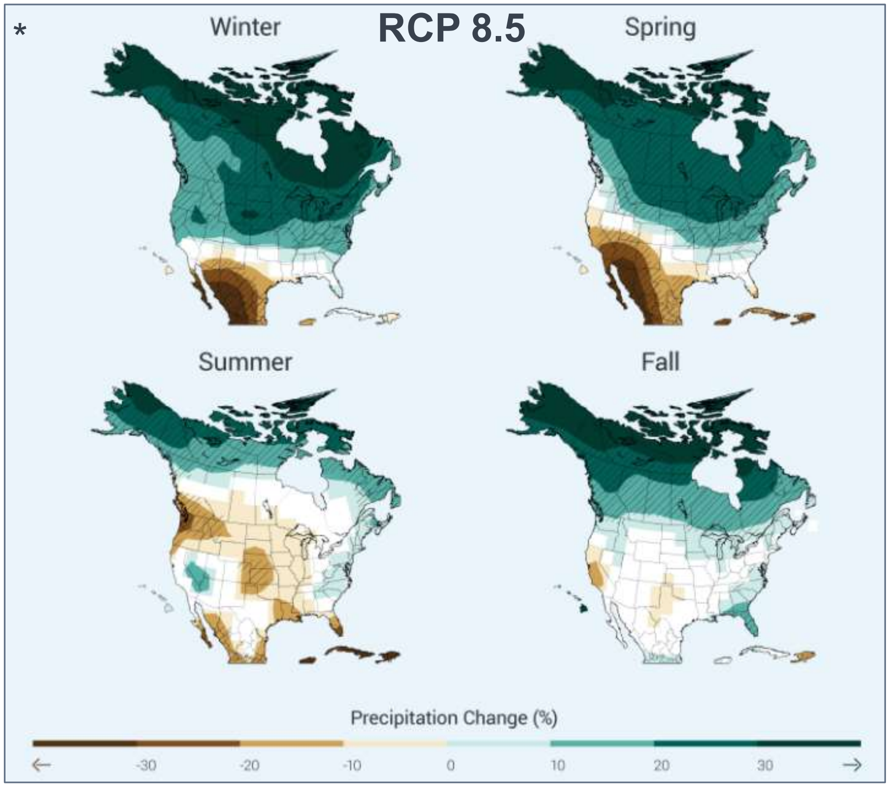
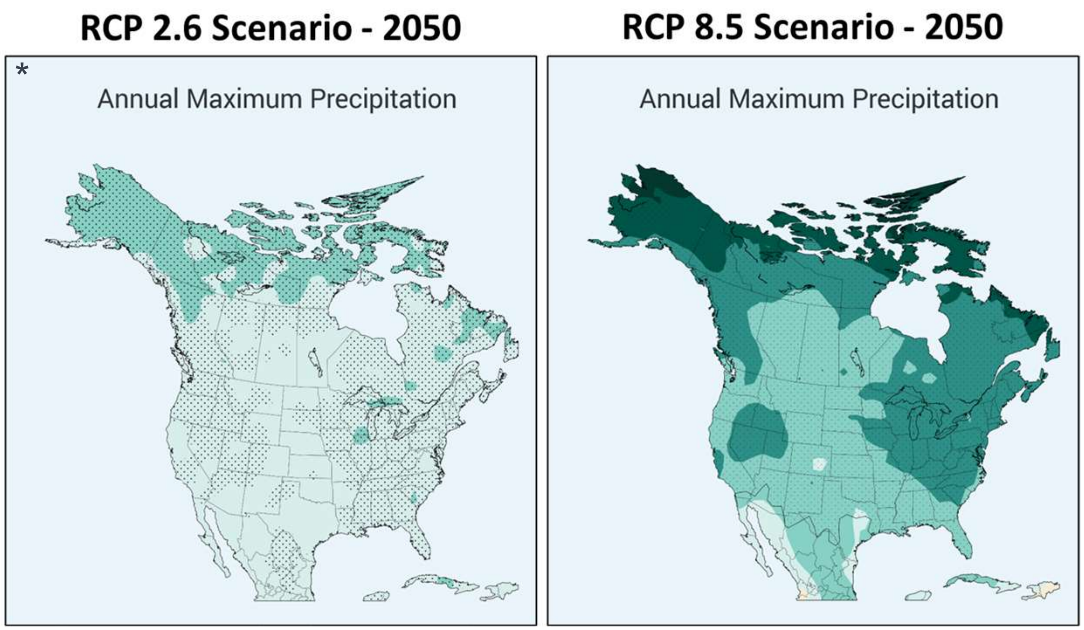
Climate Change by the Numbers



*https://nca2014.globalchange.gov/report/our-changing-climate/extreme-weather

Climate Change by the Numbers



*https://nca2014.globalchange.gov/report/our-changing-climate/precipitation-change

- Inland Flood (US)
  - Temperature increases
    - Increases holding water capacity of air, increases magnitude of precipitation events
  - Increased droughts
    - Decreases number of rain events
  - Decreased snowpack
    - Decreases spring flood events, shifts seasonal event frequency
  - Extreme events are expected to increase, overall precipitation frequency is less certain

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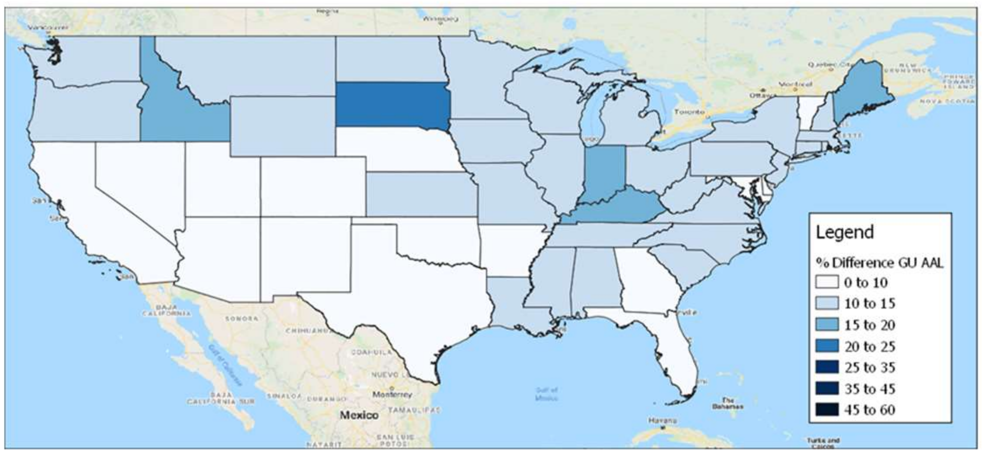
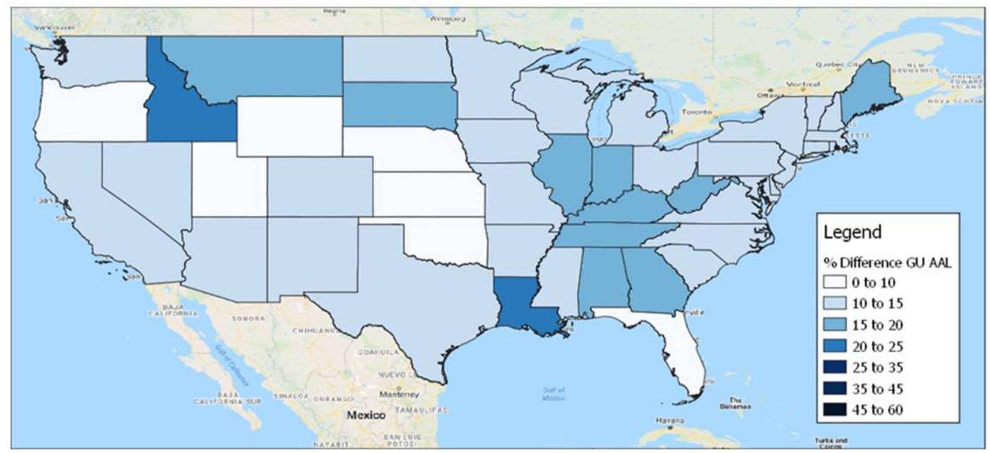
Climate Change by the Numbers

RCP 4.5 Scenario - 2050



RCP 8.5 Scenario - 2050



* Accounting for increase in temperature effect only

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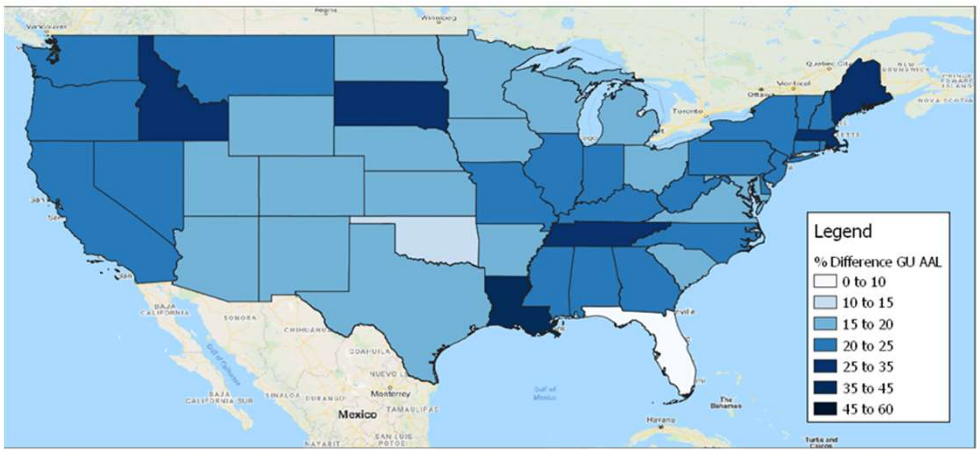
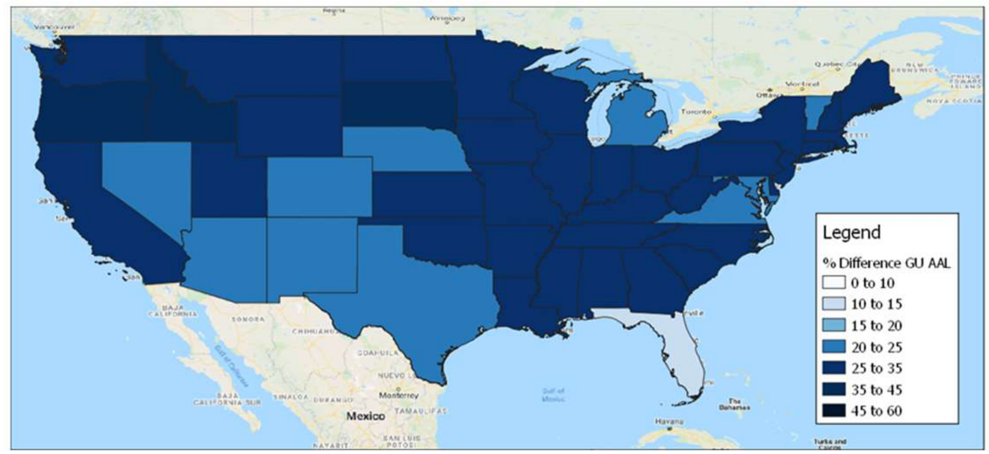
Climate Change by the Numbers

RCP 4.5 Scenario - 2100



RCP 8.5 Scenario - 2100



* Accounting for increase in temperature effect only

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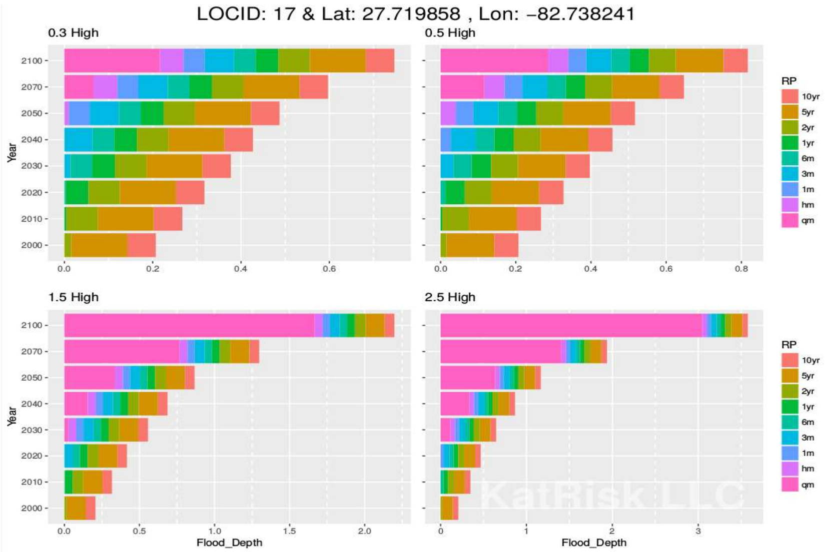
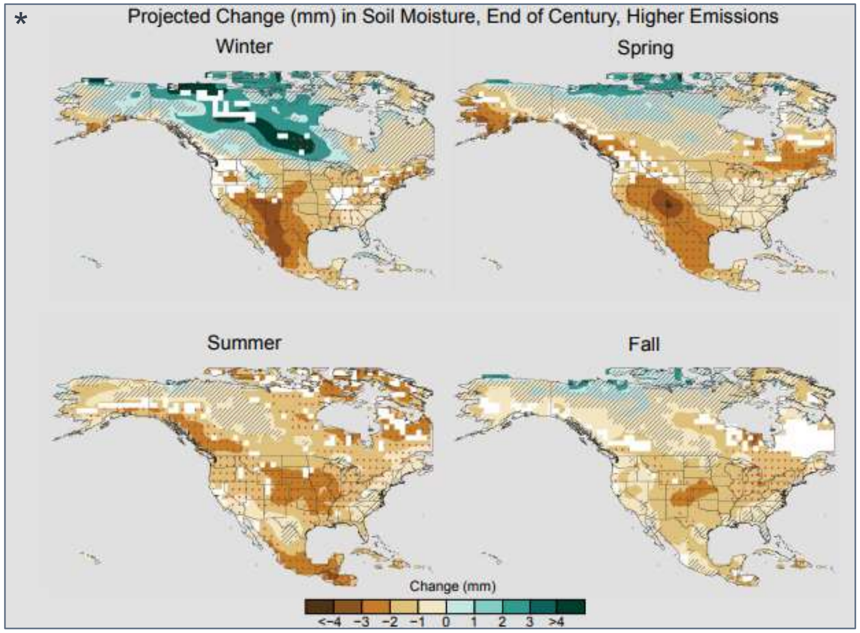
Climate Change by the Numbers

- Droughts/Wildfire
  - Increased temperature
  - Decreased mean average water table
- Sunny day flooding
  - Sea level rise increases repetitive losses





https://www.globalchange.gov/nca4

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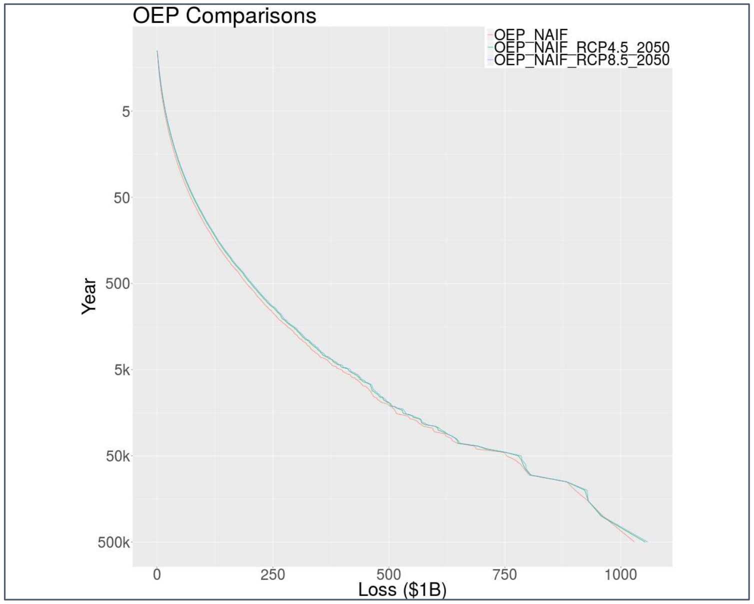
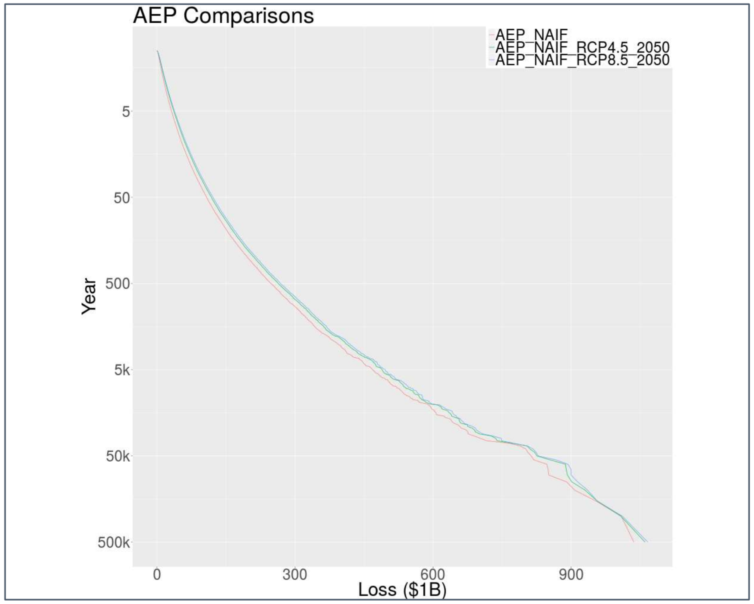
Climate Change by the Numbers

Inland Flood (11M Locations, $82T Nationwide Exposure)

	Loss in $B					
	OEP			AEP		
Return Period	NAIF Standard	RCP4.5 2050	RCP8.5 2050	NAIF Standard	RCP4.5 2050	RCP8.5 2050
10	28	31	32	50	56	58
20	44	48	49	72	80	82
50	73	78	80	108	118	122
100	102	108	110	142	154	157
200	136	143	146	182	195	200
500	193	202	205	248	264	268
1k	243	255	258	306	324	330
2k	302	312	315	370	385	391
5k	398	412	417	470	489	496
500k	1030	1053	1058	1036	1061	1067
AAL	22	25	26	22	25	26





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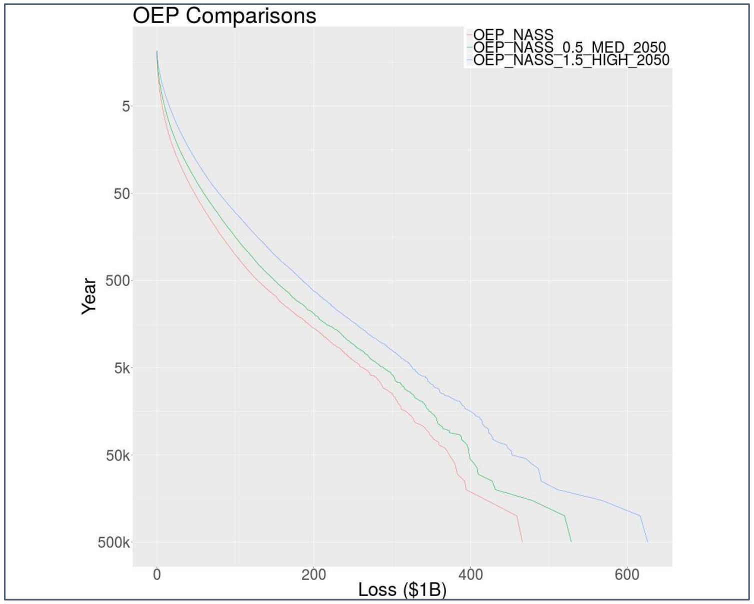
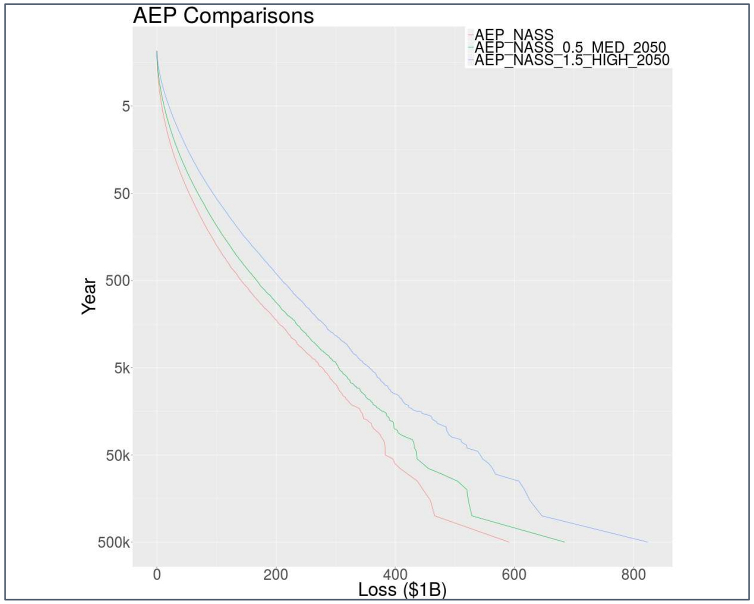
Climate Change by the Numbers

Storm Surge (11M Locations, $82T Nationwide Exposure)

	Loss in $B					
	OEP			AEP		
Return Period	NASS Standard	NASS 0.5 MED 2050	NASS 1.5 HIGH 2050	NASS Standard	NASS 0.5 MED 2050	NASS 1.5 HIGH 2050
10	14	20	30	17	24	38
20	26	34	48	30	41	59
50	48	60	79	54	69	94
100	68	83	108	76	93	125
200	91	109	139	100	123	159
500	128	150	185	141	167	210
1k	165	189	224	179	207	251
2k	208	234	268	219	249	295
5k	262	289	326	277	305	356
500k	466	529	626	591	684	824
AAL	7	9	14	7	9	14





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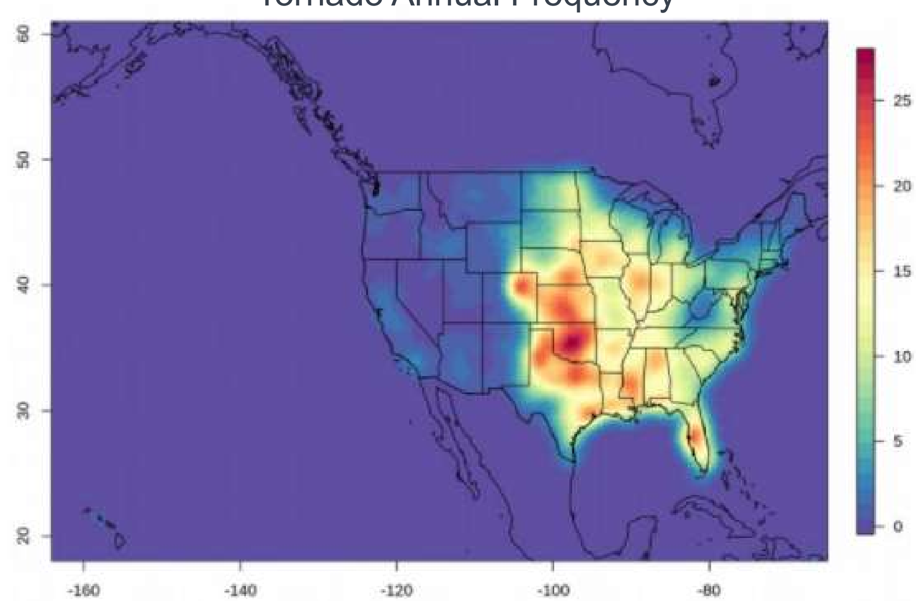
Future Work

- Compute global climate risk indices by
  - Year
  - Season
  - Month
  - Climate state (El Niño/AMO/etc.)
- Method:
  - Compute current day risk metrics for:
    - Inland flood
    - Hurricane surge/wind
    - Severe convective storm (tornado/hail/wind)
    - Extreme temperature
    - Winter storm
  - Compute same metrics using future climate states
    - Create Δ metrics

Tornado Annual Frequency



KatRisk

Thank You!

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Society of Actuaries study by Milliman and KatRisk

https://www.soa.org/resources/research-reports/2020/soa-flood-report/

- **Key mortgage questions:**
  - How could major flood events stress individual homeowners' abilities to pay their mortgages?
  - What is the downstream exposure for lenders, GSEs, mortgage guaranty insurers, and investors?
- **Methodology and assumptions:**
  - Merged single-family property data with loan data
  - Estimated flood insurance take-up rates and applied policy terms
  - Ran loan level underlying mortgage collateral through flood model
  - Analyzed uninsured impacts of major flood events (100-year and 500-year return periods)
  - Adjusted the future house price appreciation scenario for each impacted loan
  - Estimated loan level performance for underlying credit risk transfers (CRTs)

Assessing flood and climate risk to mortgages

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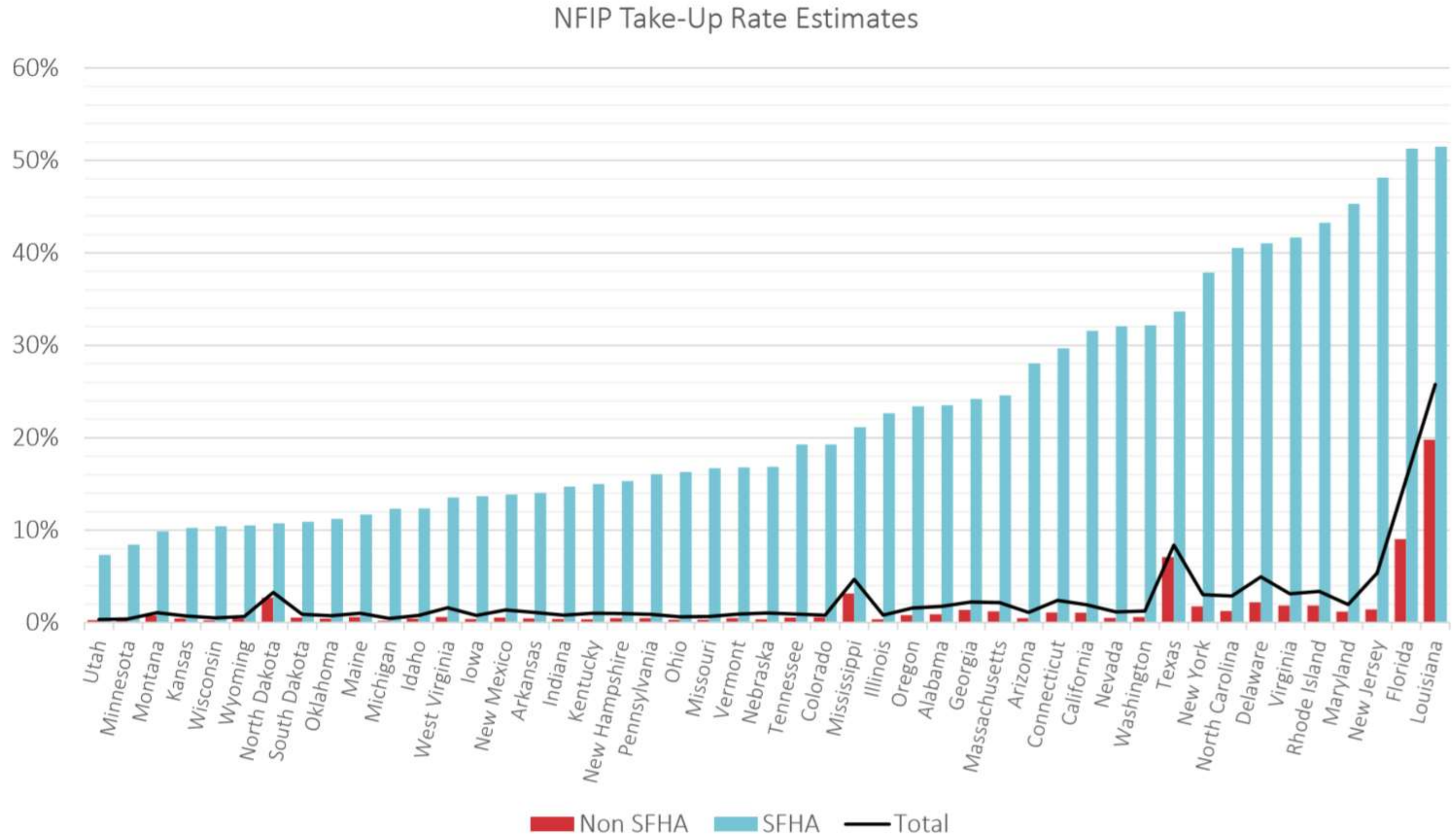
Application of insurance terms



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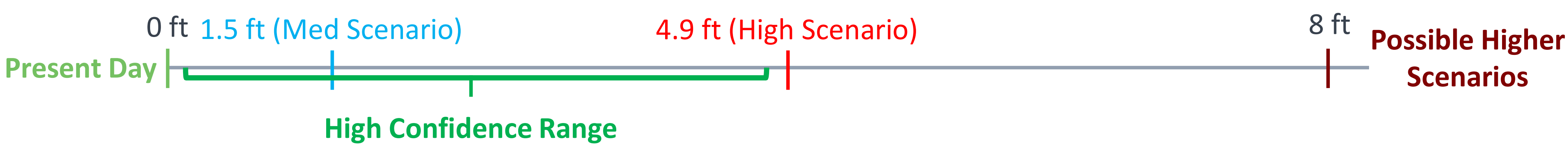
Sea level rise scenario selection

- KatRisk’s storm surge model was run with three separate sea level rise scenarios
- In addition to current sea levels, selections for this analysis were made for “**medium**” and “**high**” sea level rise scenarios. The medium regional sea level rise by 2050, with 0.5m (**1.6 ft**) globally by 2100, was selected as the medium scenario. The high regional sea level rise by 2050, with 1.5m (**4.9 ft**) globally by 2100, was selected as the high scenario.
- According to the Fourth National Climate Assessment*:
  - “Global average sea level has risen by about **7–8 inches** (about 16–21 cm) **since 1900**, with almost **half this rise occurring since 1993** as oceans have warmed and land-based ice has melted. **Relative to the year 2000**, sea level is very likely to rise **1 to 4 feet** (0.3 to 1.3 m) **by the end of the century**. Emerging science regarding Antarctic ice sheet stability suggests that, for higher scenarios, a rise **exceeding 8 feet** (2.4 m) by 2100 is **physically possible**, although the probability of such an extreme outcome cannot currently be assessed.”



*National Oceanic and Atmospheric Administration (January 2017). Global and Regional Sea Level Rise Scenarios for the United States. Available at: https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

Flood risk to mortgages modeled results

Modeled Increased Credit Losses Due to Extreme Flood Event Relative to Baseline Credit Losses

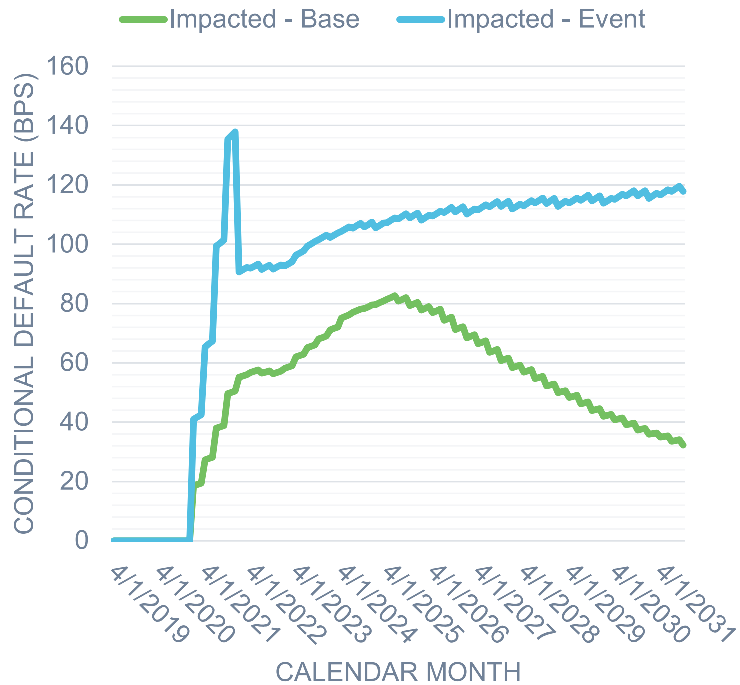
Loans Analyzed	Sea Level Scenario		
	Current	*Medium SLR*	*High SLR*
Combined Collateral Pool	4.7%	5.8%	8.0%
Riskiest Tranche	15.2%	18.5%	24.6%
Impacted Loans	373.4%	447.8%	593.0%

Percentage increases shown above are for a single extreme flood event modeled across each sea level scenario

About 50% of increased credit losses still remained after considering current mandatory purchase requirements

Significant stress for loans impacted by flood events shown by high estimated default rates post-event. Impacted is defined as homes enduring an uninsured building loss.

Modeled Conditional Default Rate of Impacted Loans



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Comparing modeled estimates to historical

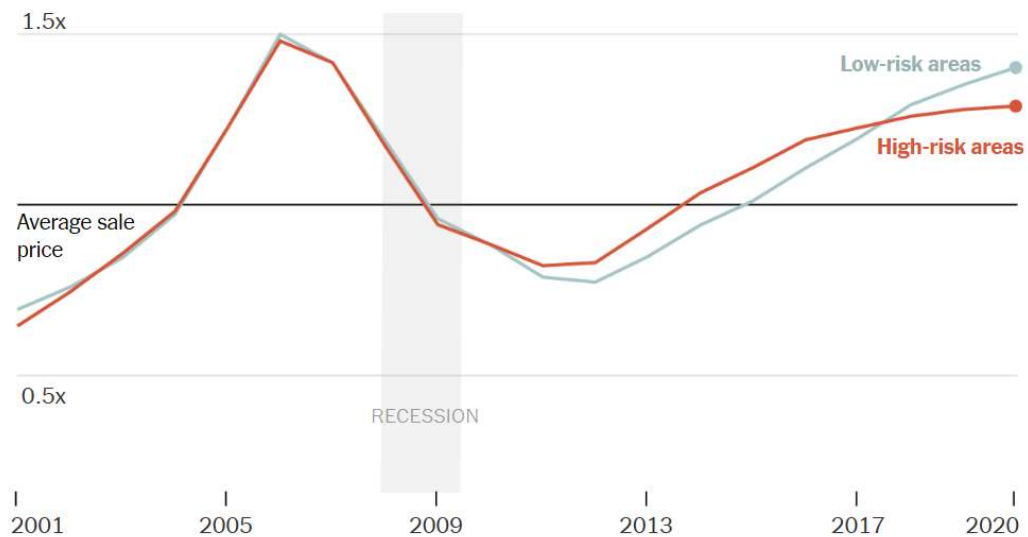
Why are modeled estimates higher than historical results?

- Delinquencies have spiked after catastrophic events, but have not materialized in foreclosures as modeled in this study
- Homeowners' desire or ability to avoid default post-disaster may have been greater than during other circumstances
- Disaster assistance offered by mortgage investors might have provided effective relief to borrowers
- State or federal assistance allowed impacted homeowners to rebuild
- Historical events may have tended to occur during periods of relative strength in the housing market

Is the historical record indicative of the future risk?

- Continuity of historical assistance into the future
- Impacts of catastrophic events within an economic downturn
- Changes in ability or desire to rebuild amidst climate change threats and impacts

Florida Sees Signals of a Climate-Driven Housing Crisis



Source: Keys and Mulder, National Bureau of Economic Research
https://www.nytimes.com/2020/10/12/climate/home-sales-florida.html

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Thank you

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