Flood for Thought

2020 RPM Virtual Seminar
July 27, 2020

Speakers:

Brandon Katz, Katrisk
David D. Evans, Milliman
David Atkinson, FEMA
Howard Kunst, CoreLogic

Flood Modeling

Brandon Katz, M.Sc.

Katrisk

KatRisk

Questions to Answer

1. How are flood catastrophe models composed and what is different about flood vs other hazard models?

2. How will climate change influence Flood Catastrophe Models

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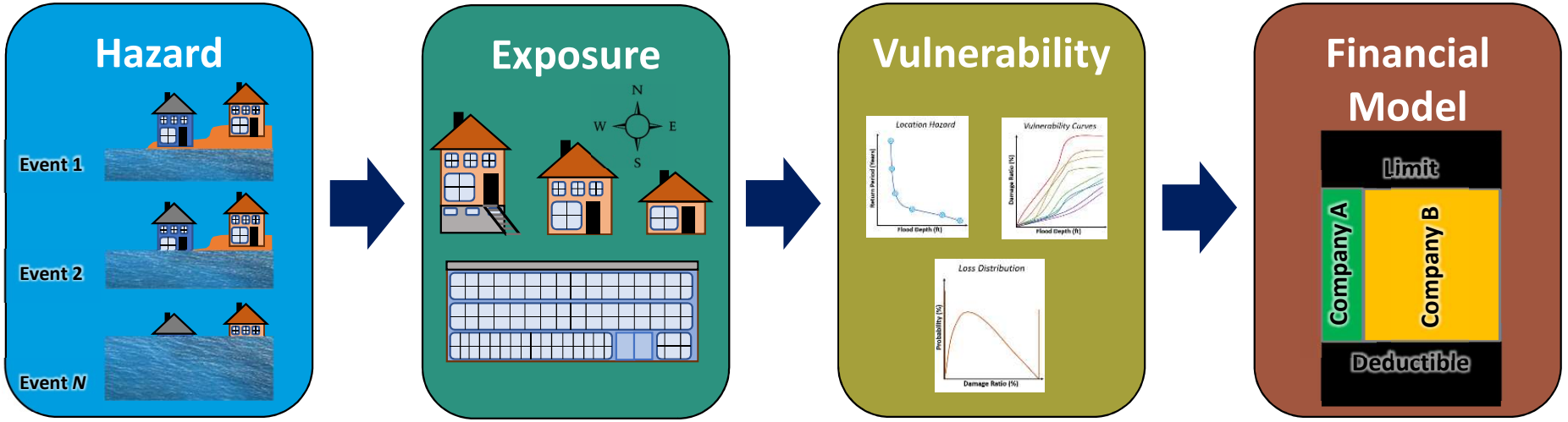
Flood Catastrophe Modelling



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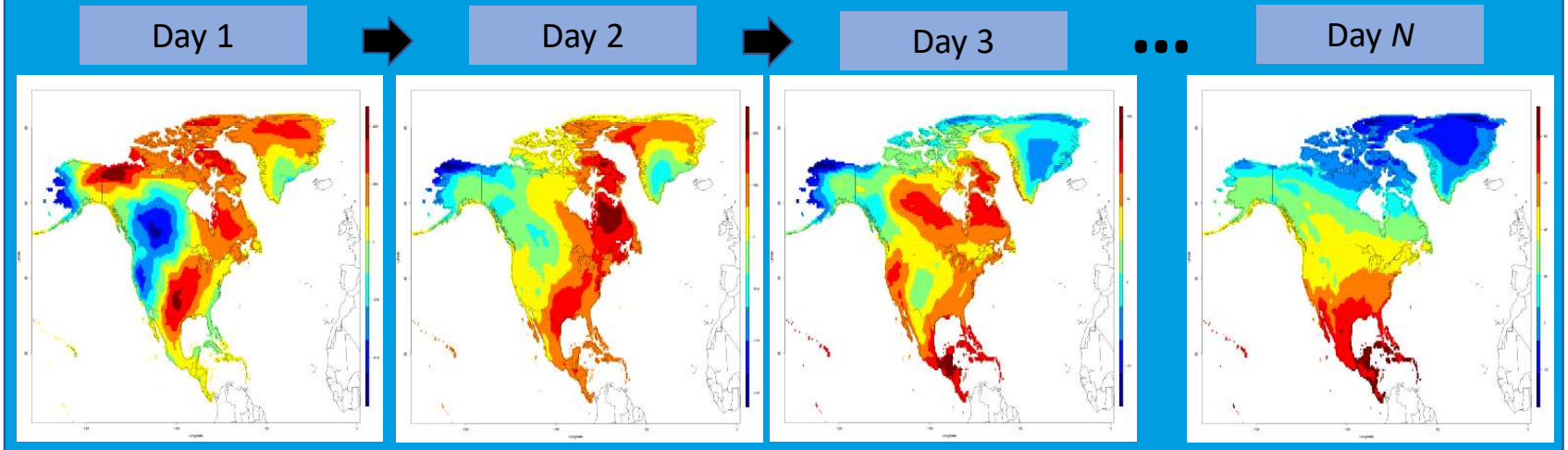
Flood Catastrophe Modelling

Create stochastic inputs, sub-daily temperature, precipitation, etc. for thousands of years



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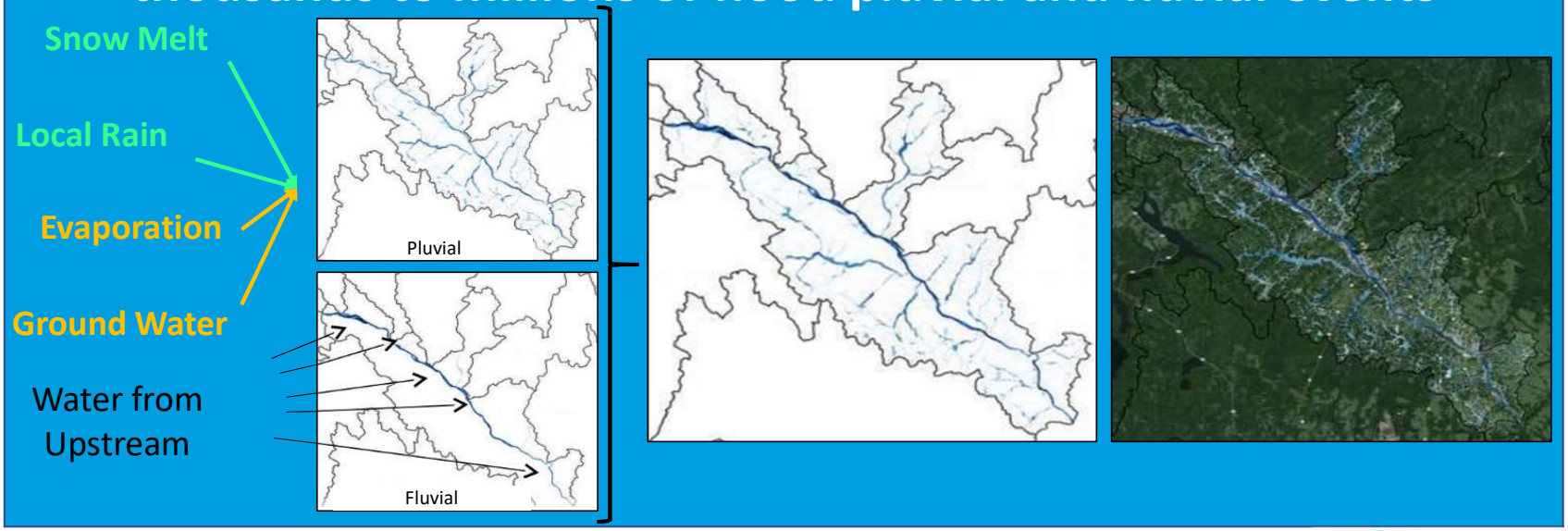
Flood Catastrophe Modelling

Daily inputs drive hydraulic/Hydrologic models, resulting in thousands to millions of flood pluvial and fluvial events



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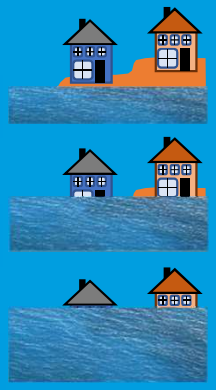
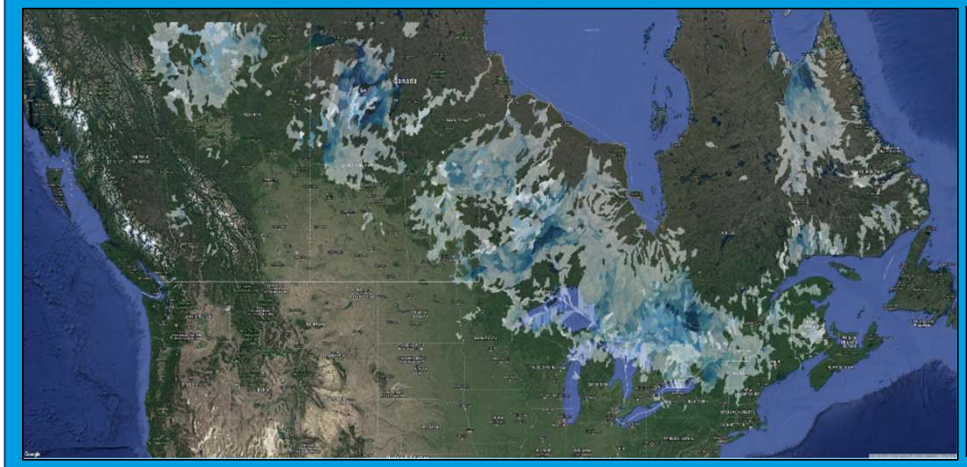
Flood Catastrophe Modelling

Hazard



Generate Events from Simulations



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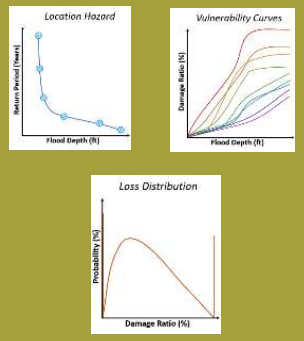
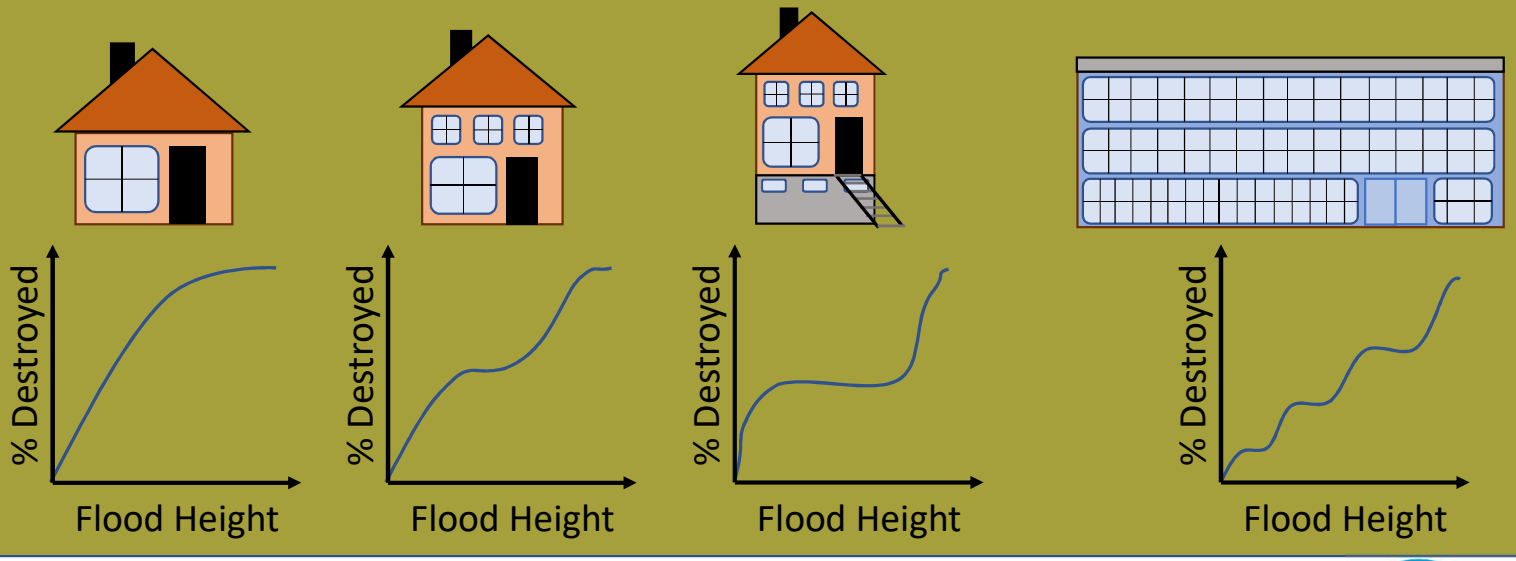
Flood Catastrophe Modelling

Vulnerability



Vulnerability tells us how damaged a structure will be given a hazard (ex/ 1 vs 2 feet of flood)



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Flood Catastrophe Modelling

Financial Model

The financial model can be as straightforward or as complex as required

Single Location

- ❑ Limit
- ❑ Deductible

Single Location

- ❑ Limit
- ❑ Deductible
- ❑ Coverage Deductible
- ❑ Earthquake Deductible
- ❑ Windstorm Deductible

Portfolio with Reinsurance

- ❑ Limits
- ❑ Deductibles
- ❑ Coverage Deductibles
- ❑ Earthquake Deductibles
- ❑ Windstorm Deductibles
- ❑ Site Limits
- ❑ Site Deductibles
- ❑ Blanket Deductibles
- ❑ Quota Share Reinsurance Treaties
- ❑ Etc.

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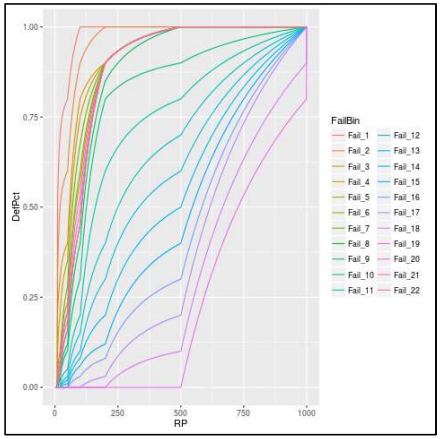
Flood Catastrophe Modelling

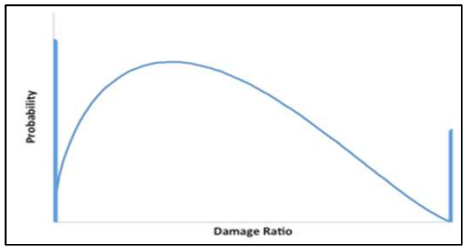
Loss Model (Defense, Vulnerability, Uncertainty)

1. Determine Defense
2. Map Vulnerability Curves
3. Sample Vulnerability Loss Curve

Defense Fragility Curves



4-Parameter Beta Distribution



KatRisk Vulnerability Modifiers

First Flood Elevation		Unit Start/End Floor		Basement Only	
Occupancy	Construction	Number of Stories	Basement	Mobile Home Tie Down	Finished Basement
Residential	Wood	1	Yes	Yes	Yes
Commercial	Masonry	2	No	No	No
Industrial	Concrete	3	Unknown	Unknown	Unknown
Auto	Steel	>3			
Unknown	Light Metal	Unknown			
	Mobile Home				
	Unknown				

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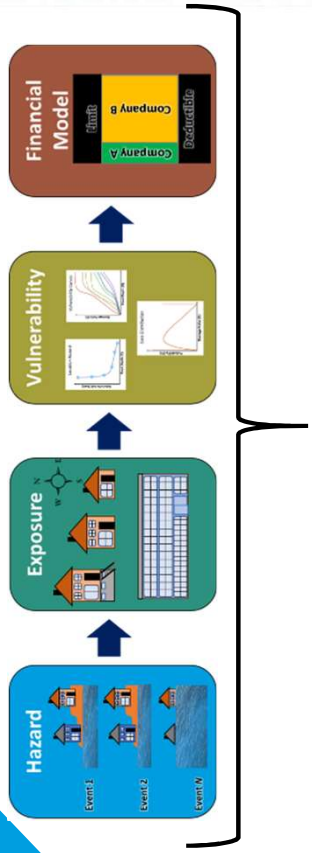
Flood Catastrophe Modelling



Event Loss Table (ELT)

Event ID	Loss
1574425	51,235
1574625	65,412
1000215	51,581
988878	0
…	
TOTAL	$10B

Loss Statistics

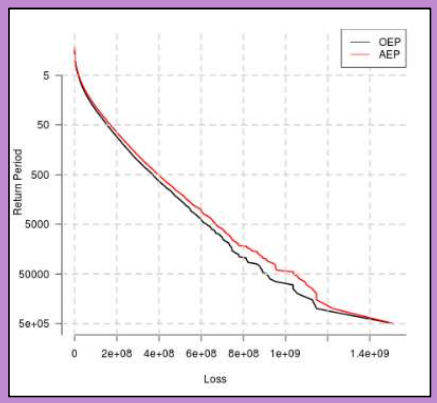
Average Annual Loss (AAL) [aka Pure Premium]

Assuming 10k years of events:

$$AAL = \frac{\$10B}{10k}$$

$10,000

Exceedance Probability Curve (EP)



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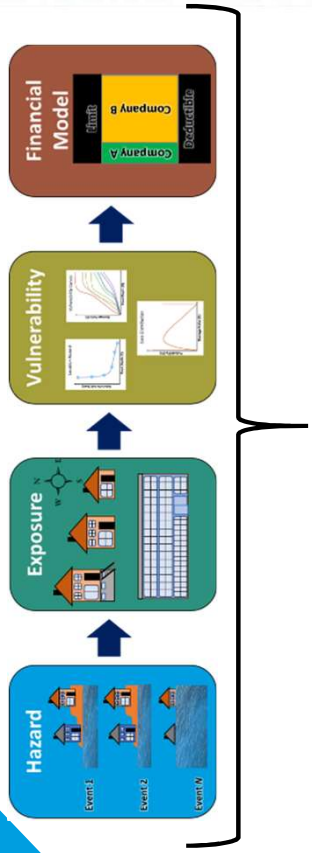
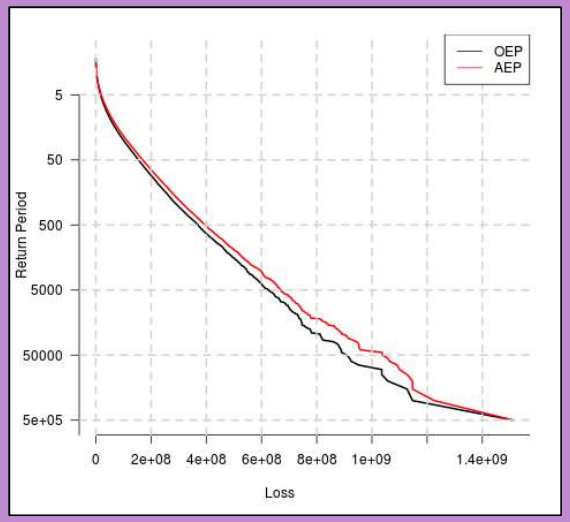
Flood Catastrophe Modelling



Loss Statistics - OEP vs AEP



OEP
Occurrence Exceedance Probability

- If you have, say 500k years of events:
  - Take the event with the highest loss every year and order the losses

AEP
Aggregate Exceedance Probability

- If you have, say 500k years of events:
  - Sum all the events for each year and order the losses

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Flood vs. Other Hazards?

Resolution

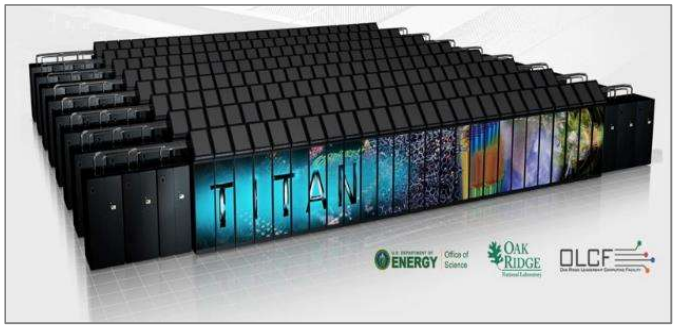
- Compute Time
- Run Time
- Geospatial Accuracy

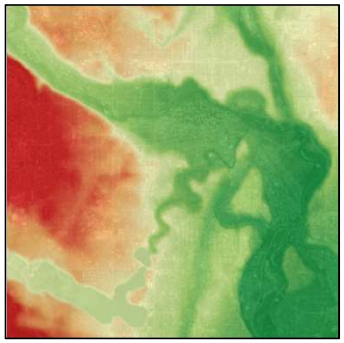
Data Availability

- High Resolution Input Data
- Historic Loss Data

Demand

- NFIP





NATIONAL FLOOD INSURANCE PROGRAM

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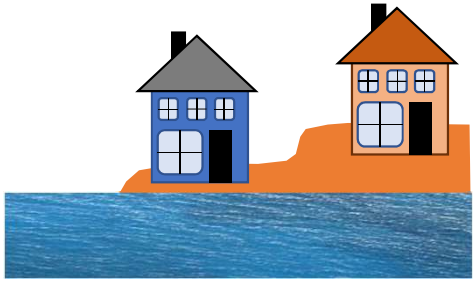
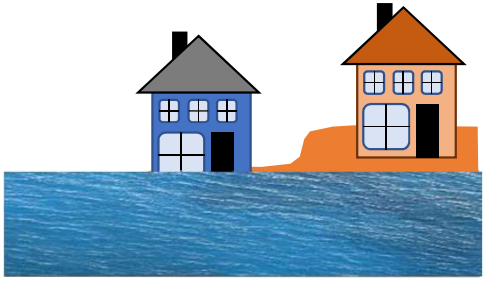
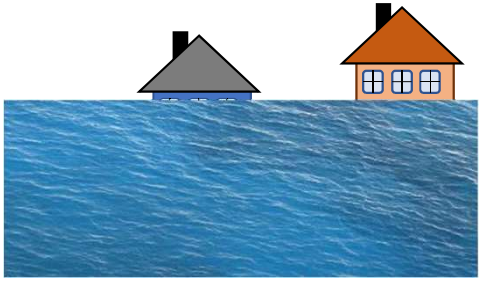
Climate Uncertainty (Storm Surge)



- X cm Current Day Mean Sea Level



Current Day Mean Sea Level



+ X cm Current Day Mean Sea Level

Change Global Sea Level

Increases/Decreases loss due to TC Storm Surge

Change Local Sea Level

Raster Lookup, mean sea level change can be different by location

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Society of Actuaries Study by Milliman | KatRisk

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

Figure 6: Storm Surge Losses by MSA and Sea Level Rise Scenario

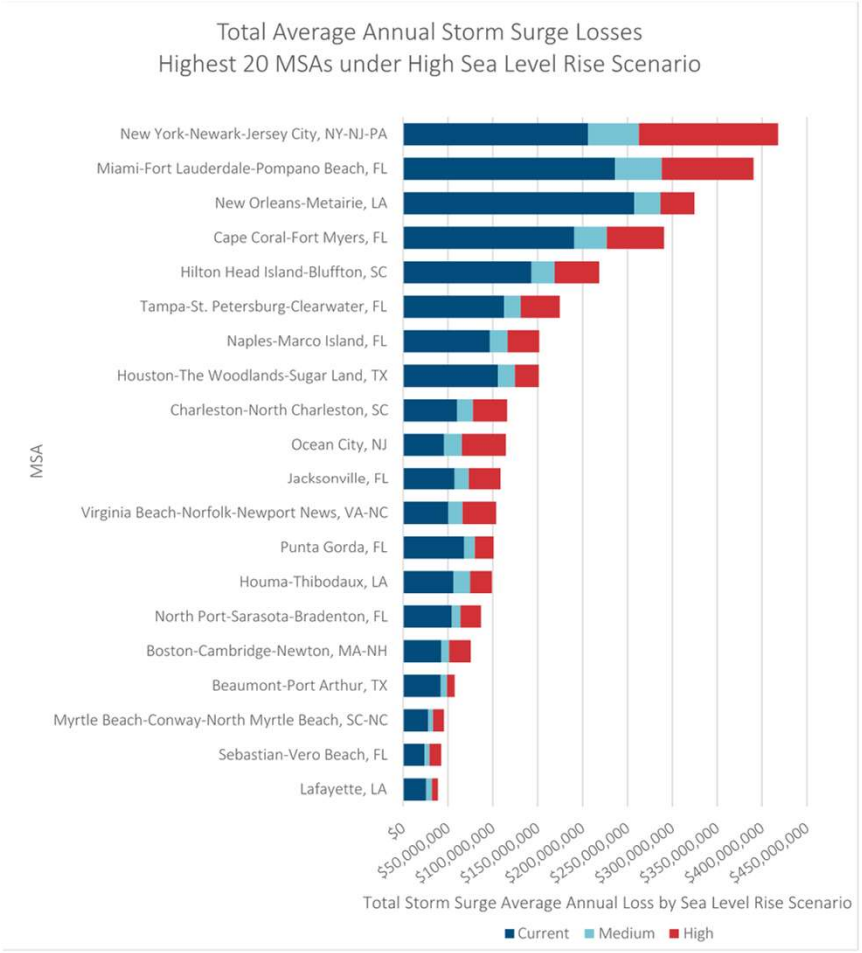
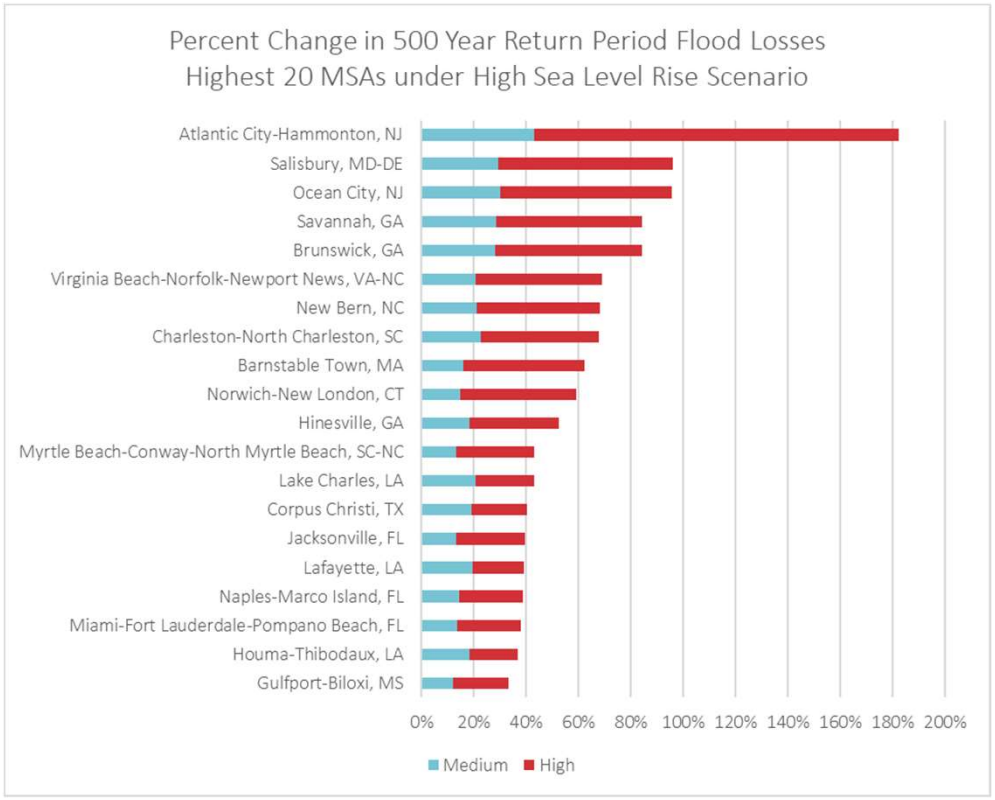


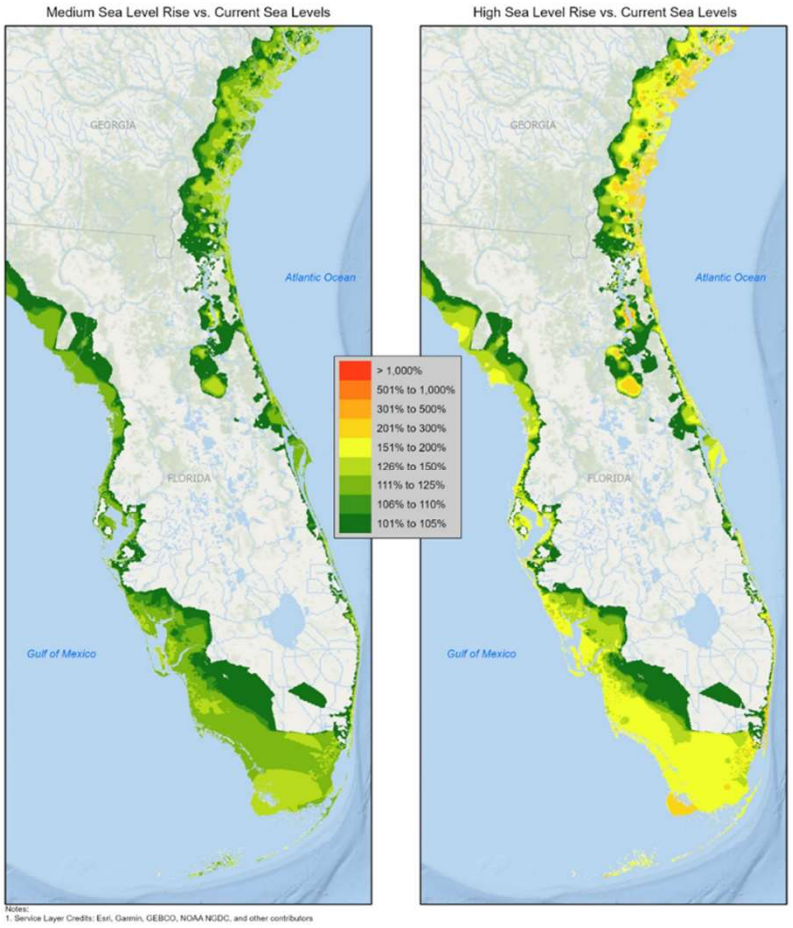
Figure 8: Change in 500-year Return Period Flood Losses for Sea Level Rise Scenarios Compared to Current Sea Levels



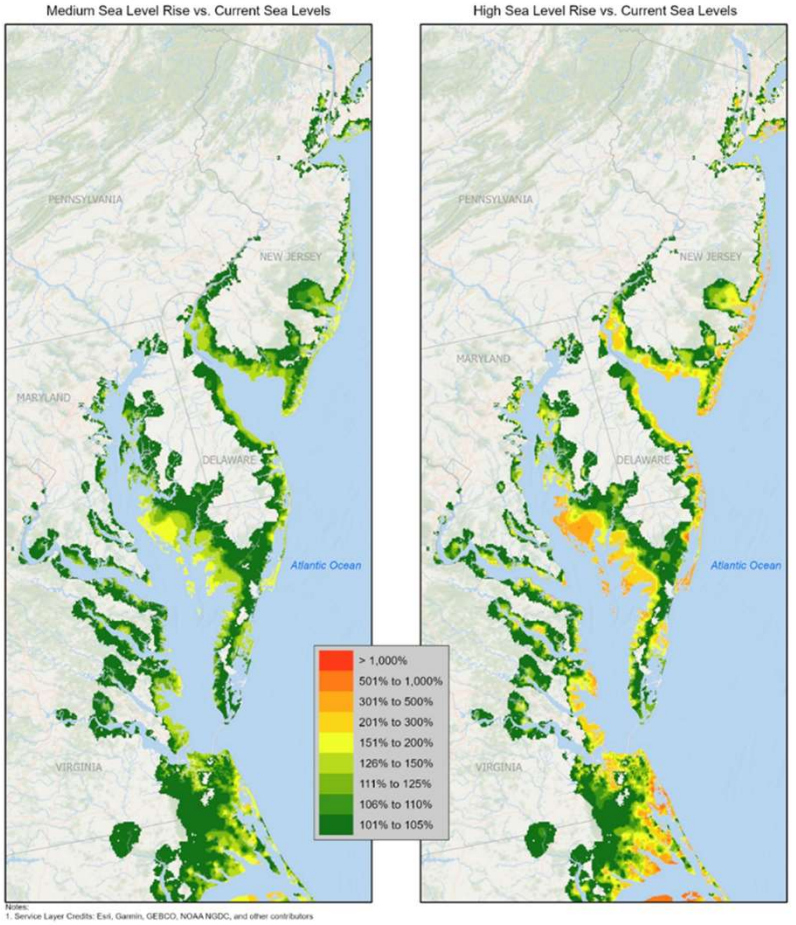
Society of Actuaries Study by Milliman | KatRisk

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

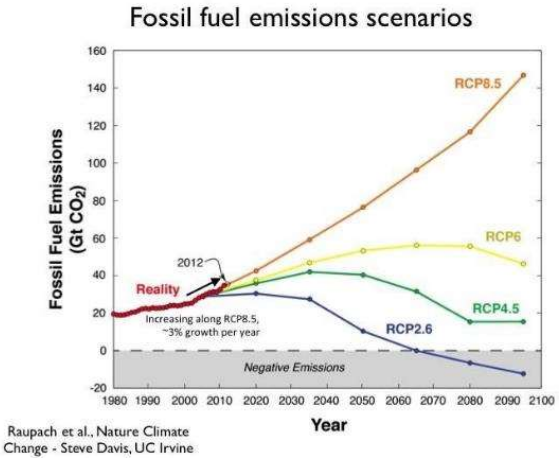
Map 2: Expected Flood Losses; Sea Level Rise Scenarios to Current Sea Level - Florida to Georgia



Map 4: Expected Flood Losses; Sea Level Rise Scenarios to Current Sea Level – Mid-Atlantic

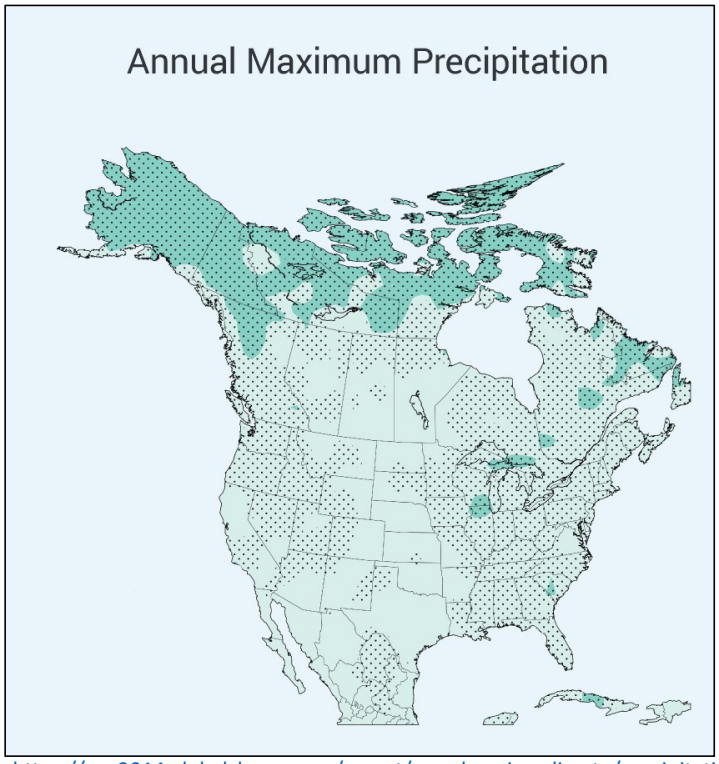


Climate Uncertainty (Inland Flood)

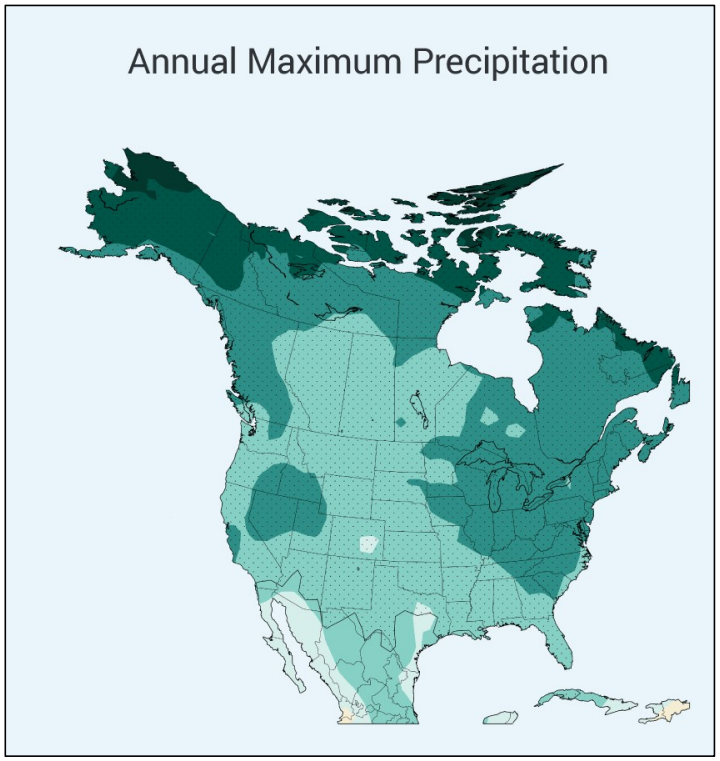


Raupach et al., Nature Climate Change - Steve Davis, UC Irvine

RCP 2.6 Scenario - 2050



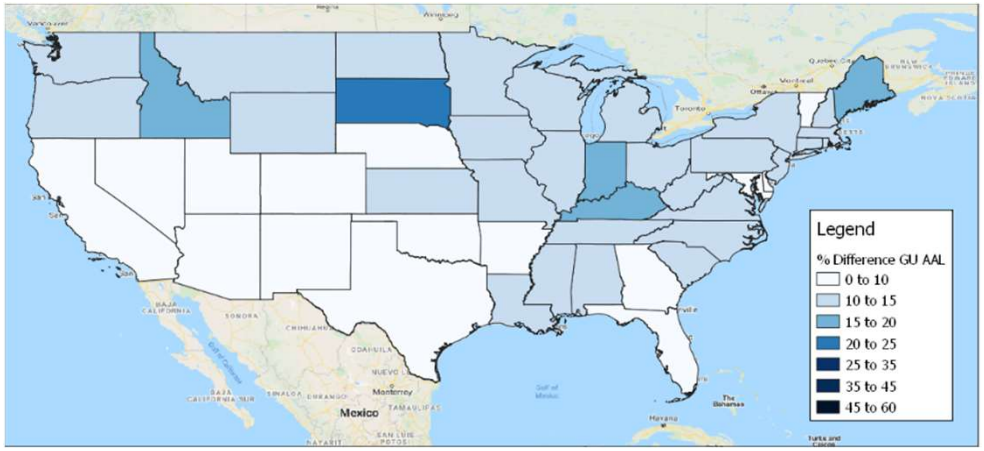
RCP 8.5 Scenario - 2050



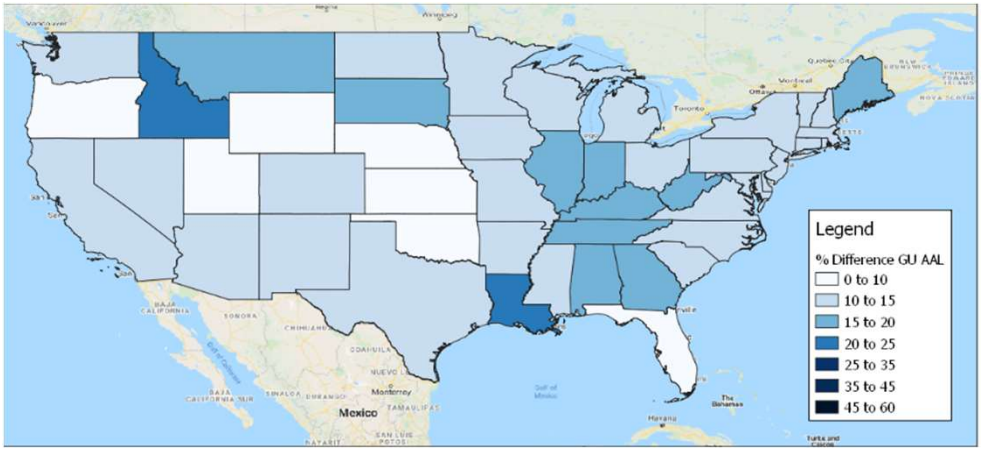
https://nca2014.globalchange.gov/report/our-changing-climate/precipitation-change

Climate Uncertainty (Inland Flood)

RCP 4.5 Scenario - 2050



RCP 8.5 Scenario - 2050



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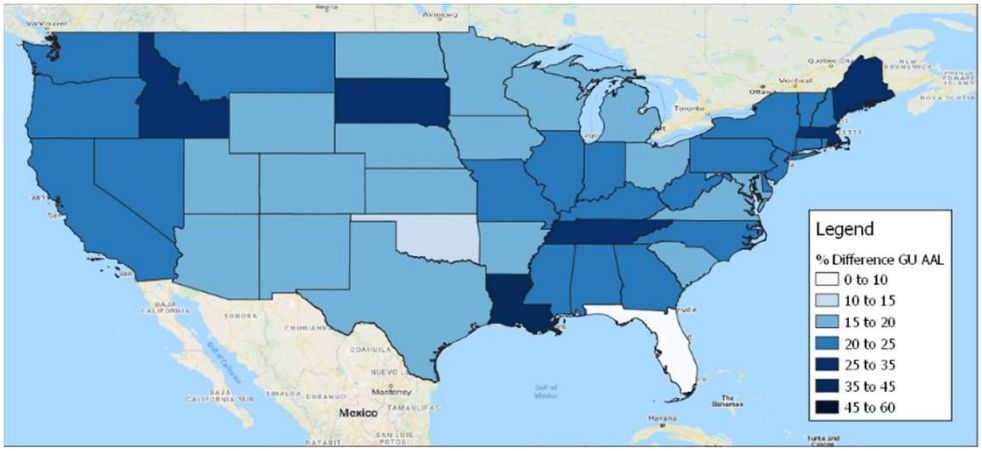
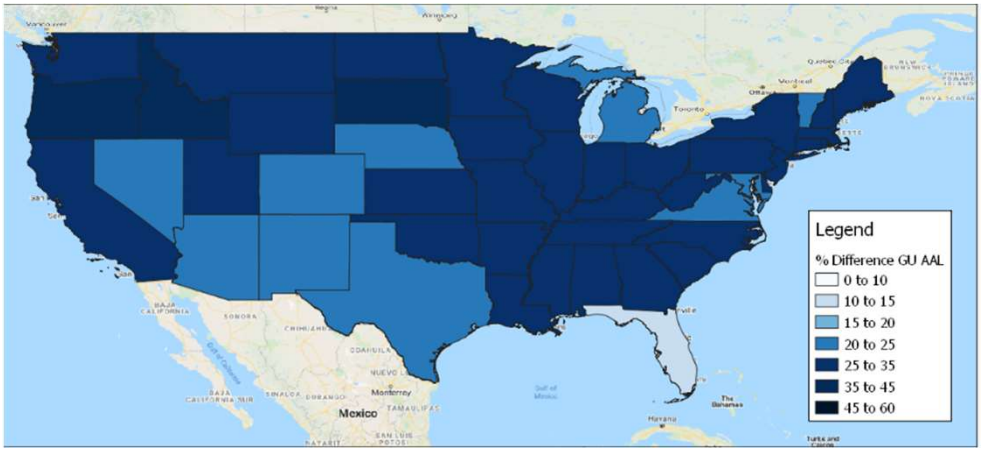
Climate Uncertainty (Inland Flood)

RCP 4.5 Scenario - 2100



RCP 8.5 Scenario - 2100



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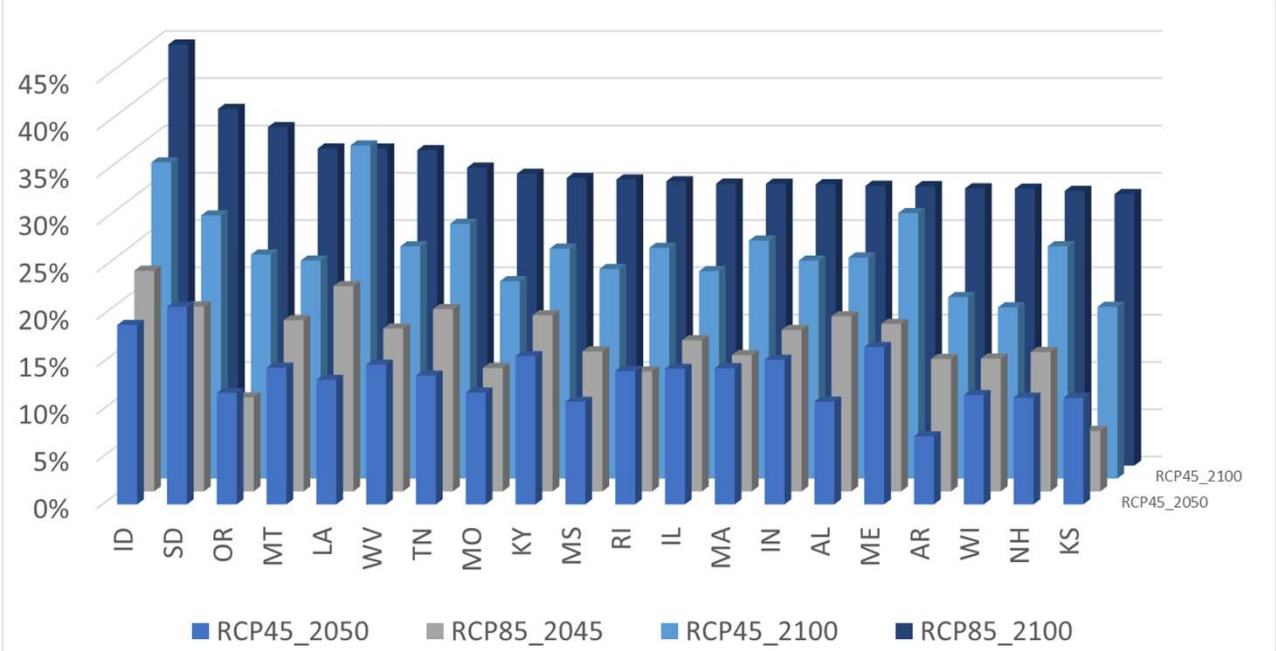
Climate Uncertainty (Inland Flood)

Percent Change in Ground Up Average Annual Loss By State (Top 20 by % Change)



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Thank You!

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Current state and trends of the Private Flood Market

David D Evans, FCAS

Milliman

David.d.evans@Milliman.com

Traditional obstacles for private flood insurers

- Flood risk varies significantly over a short distance
- Lack of data and experience
- Catastrophic potential and interaction with wind
- High potential for a small number of risks to drive losses
- Fragmented state regulatory market

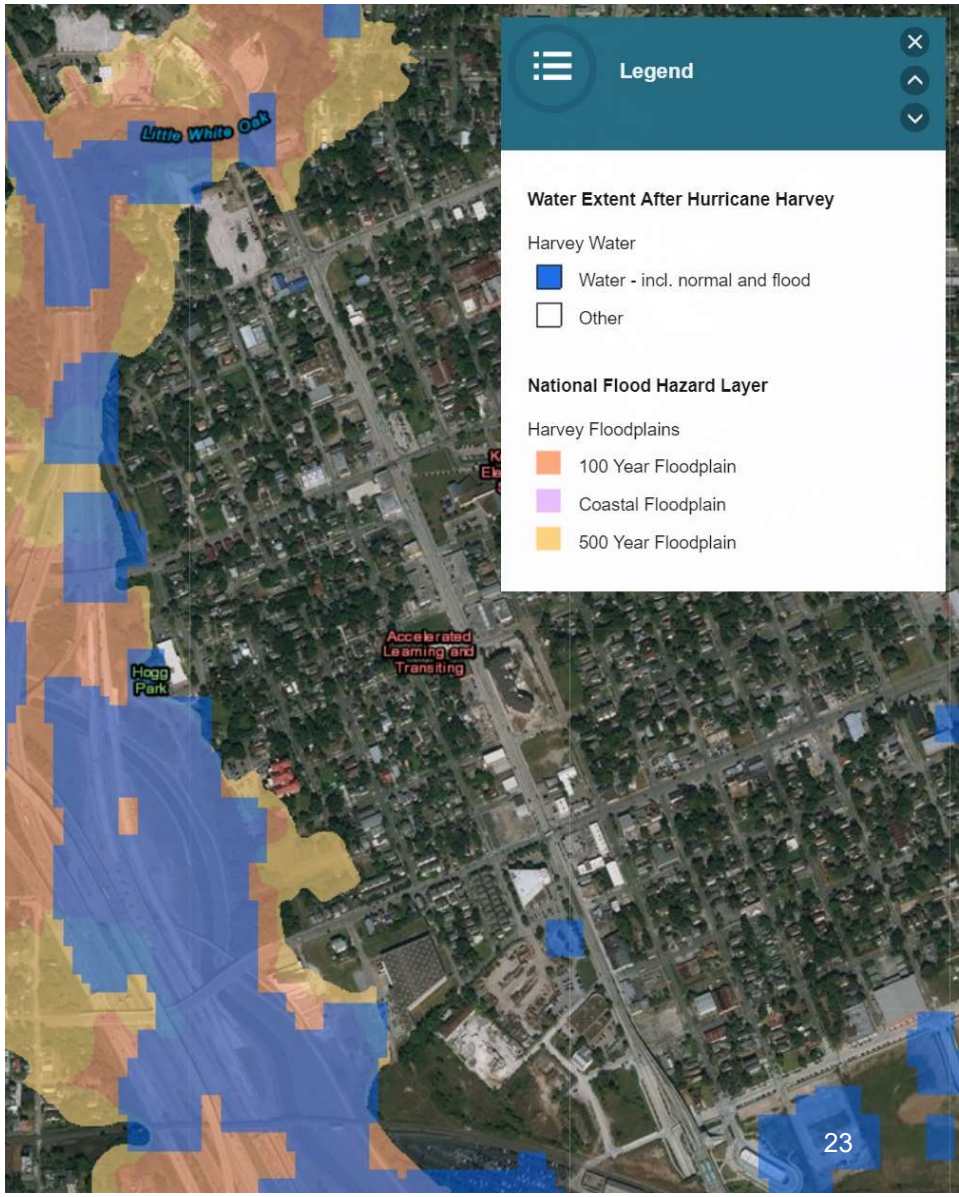
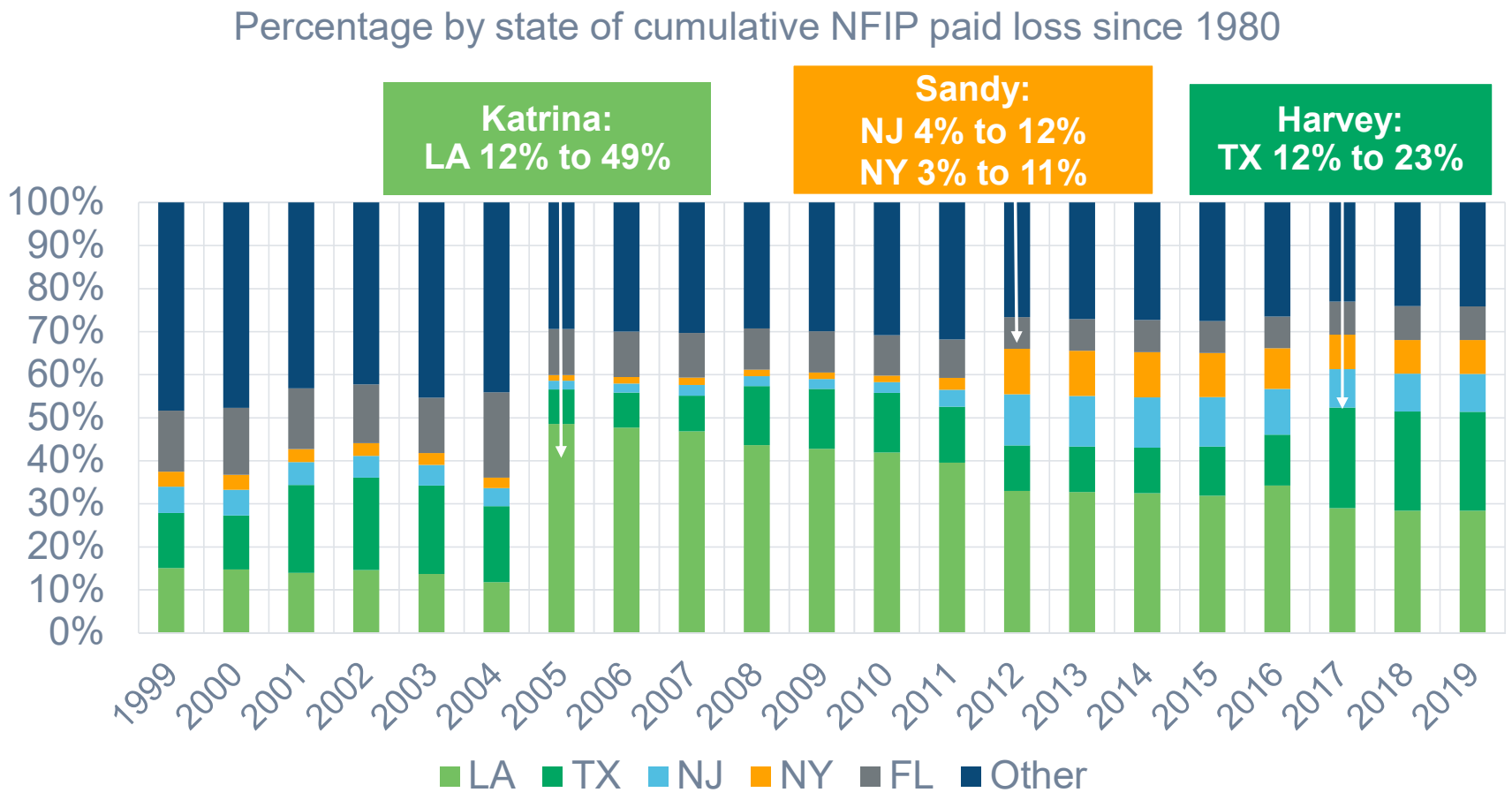


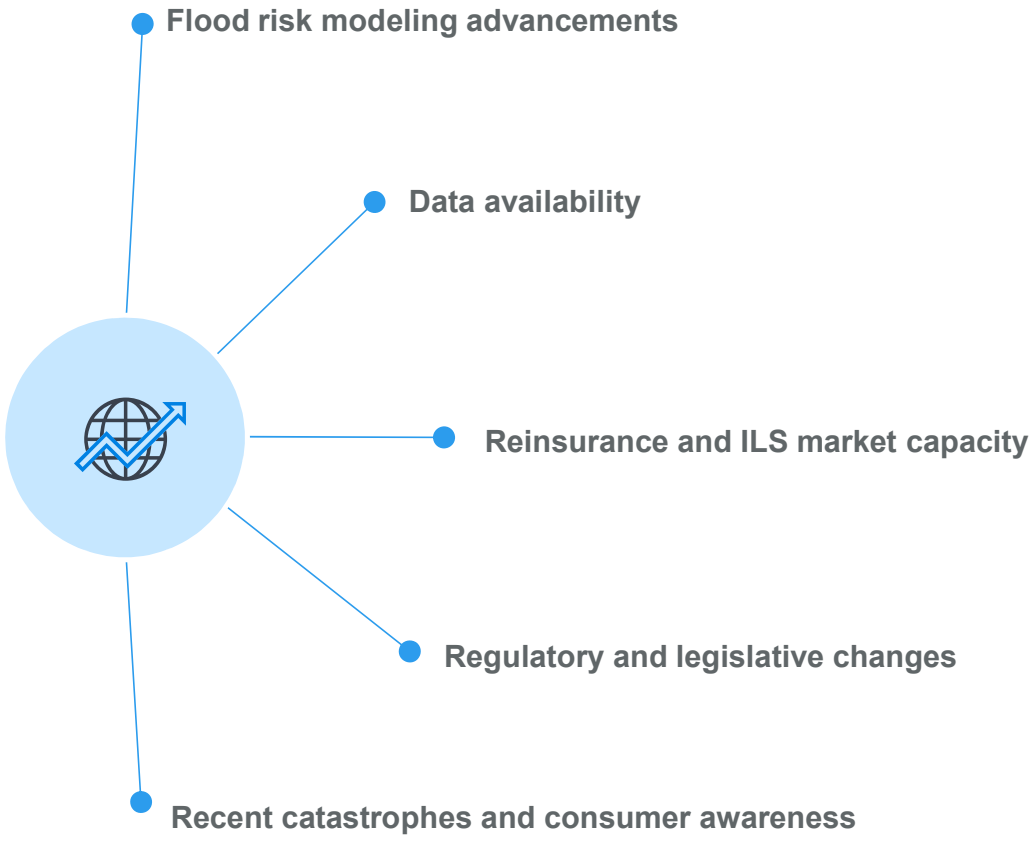
Image Source: Hurricane Harvey Water Extent (Estimated)
UC Davis Center for Watershed Sciences

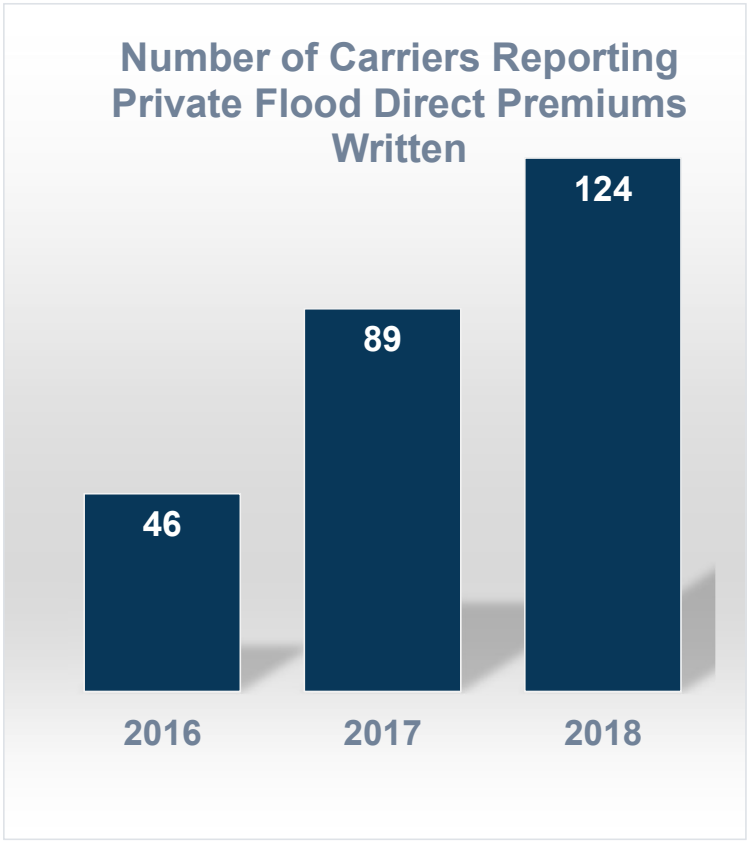
Historical data is too volatile for flood ratemaking



Source: OpenFEMA data June 2019

Why are insurance companies starting to insure flood?





Source: Carrier Management

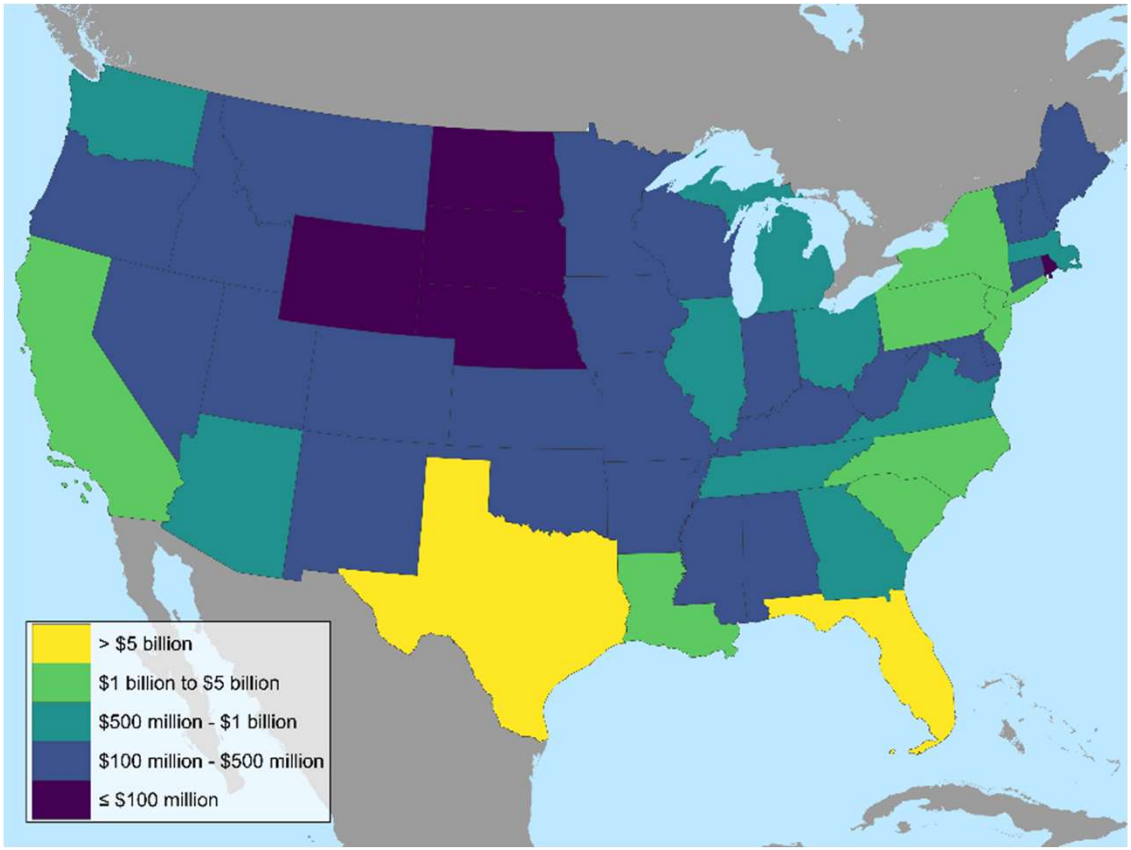
Flood insurance by the numbers

Statistics on the U.S. residential flood market

- 2019 Homeowners Direct Written Premium (DWP) was $103B
- **Milliman estimate: the potential U.S. residential flood insurance market is _____ of DWP**
  - A) $37M to $47M
  - B) $370M to $470M
  - C) $3.7B to $4.7B
  - D) $37B to $47B

Potential market is magnitudes larger than the current

- **Milliman estimate: the potential U.S. residential flood insurance market is D) $37B to $47B of DWP.**
- Estimate includes insured losses, expenses and profit. Expenses includes costs of reinsurance.
- Estimate does not include minimum premium
- Policy terms assumed similar to homeowners
- Estimate assumes flood insurance purchased at a rate similar to residential property insurance today



Flood insurance by the numbers

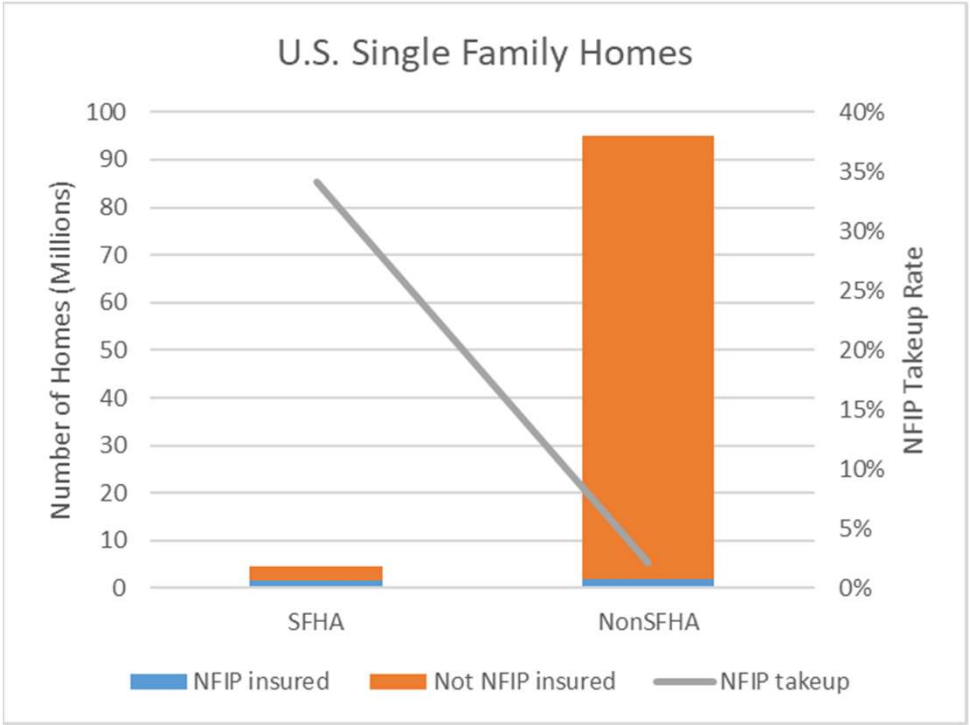
Statistics on the U.S. residential flood market

- **2018 NFIP and Private Flood reported Earned Premium for personal and commercial lines combined was:**
  - A) $4B
  - B) $14B
  - C) $24B
  - D) $40B

Flood insurance by the numbers

Statistics on the U.S. residential flood market

- **2018 NFIP and Private Flood reported Earned Premium for personal and commercial lines combined was A) $4B**
- 2018 NFIP Earned Premium was $3.3B, with about $700M reported for Private Flood line
- Additional flood market estimates:
  - Only 5% of U.S. single-family homes had a flood insurance policy in 2018
  - From SOA study: 87% of single-family flood losses are uninsured



Take-up rate challenges

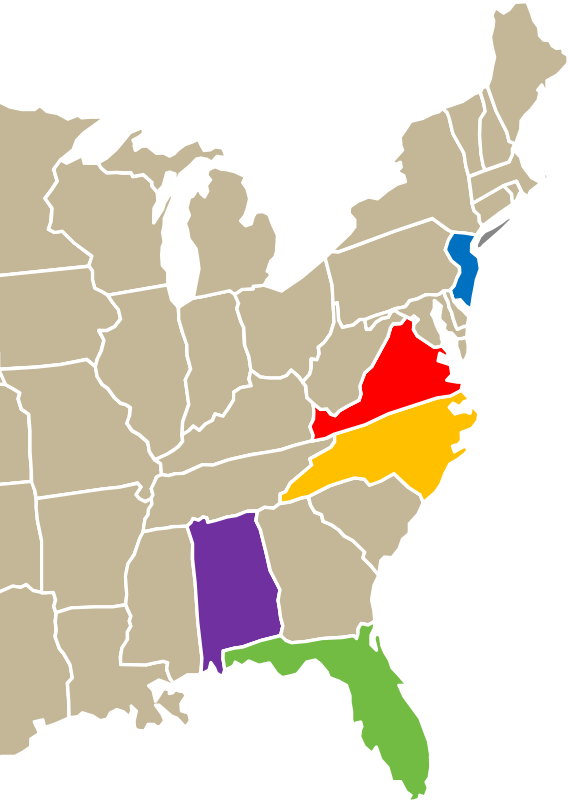
Protection gap between current and potential market driven by low take-up rates

National take-up rates (those with flood coverage)	Possible explanations			
▪ Approximately one-third of single-family homes in Special Flood Hazard Area have an NFIP policy. ▪ This is only about 2% outside the SFHA	▪ Flood coverage is perceived to be too expensive	▪ Many people believe that if flood insurance is not required as a condition of a mortgage, they are not at risk of a flood	▪ Some believe flood coverage is only available for properties in flood zones	▪ Others believe flood coverage is a standard inclusion in their homeowners policy ▪ This is supported by a disconnect in consumer surveys vs. take-up data

Sources: Milliman estimates, NAIC CIPR Study on Flood Risk and Insurance, April 2017

States taking action to encourage private flood

States are encouraging companies to close the protection gap



New Jersey	Recognized need for robust private flood market post-Sandy	*Action:* Deregulated rates, rules, and forms by putting flood on export list
Virginia	Regulations required all models or final rates to be filed	*Action:* Issued administrative order in 2019 suspending rate and support filing requirements through 2025
North Carolina	Rates and forms must be promulgated by rating bureau	*Action:* NCRB developed state of the art flood program; approved by DOI in February 2020
Florida	Property rate regulations were too burdensome for flood, and flood model standards were not yet established	*Action:* Passed SB 542 allowing freedom in flood rating and use of cat models subject to informational filings, future model review
Alabama	State is exposed to significant flood risk, but consumers have limited choices to purchase flood insurance outside NFIP	*Action:* Commissioned survey of insurers, reinsurers, MGAs, other stakeholders to identify actions the state could take to encourage private flood market

Thank you!

Source: OpenFEMA data June 2019

FEMA

National Flood Insurance Program

Casualty Actuarial Society

RPM Conference

July 27, 2020

NFIP History

National Flood Insurance Act of 1968

- Unavailability of private flood insurance. Viewed as an uninsurable risk.
- Provide more complete and dependable coverage than relying solely on federal disaster assistance.

Property owner must be in a participating community that has adopted floodplain management regulations and a Flood Insurance Rate Map (FIRM) that indicates relative riskiness of different areas by zone: AE, V, X, etc.

Main NFIP Products

Flood Insurance Policies, including Standard Risk and Preferred Risk Policies (PRP).

https://www.fema.gov/national-flood-insurance-program

Flood Plain Management, Minimum Building Standards.

https://www.fema.gov/floodplain-management

Flood Risk Identification

Flood Map Service Center

https://msc.fema.gov/

NFIP Relationship with Industry

Write Your Own (WYO) Program

- Great majority of NFIP policies are sold and handled (including claims) by industry partners. NFIP ultimate risk bearer.

Private Flood Insurers

- Private insurers gradually gaining an appetite for flood insurance.
- Driven by catastrophe modeling and sophisticated analytical methods.

NFIP buys private reinsurance and places Insurance Linked Securities (ILS) in the capital markets. (Fairly recent development)

NFIP Relationship with Industry (cont'd)

FEMA encourages greater private market participation. Our hope is to close the flood insurance "gap"---too few Americans are protected by flood insurance. Only about 20% of homes flooded in Hurricane Harvey had flood insurance.

OpenFEMA: FEMA publishes policy and claims data for anyone to use. See https://www.fema.gov/openfema. Data is not available at precise location level in order to protect privacy, but is available at census tract, county, zip code, and latitude/longitude to 1 decimal place levels.

NFIP Transformation

Risk Rating 2.0 aims to deliver several key benefits:

Provide rates that are easier to understand for agents and policyholders.

Simplify and standardize the quoting process across the country.

Create a more individualized picture of a property's risk.

Communicating Local Flood Risk

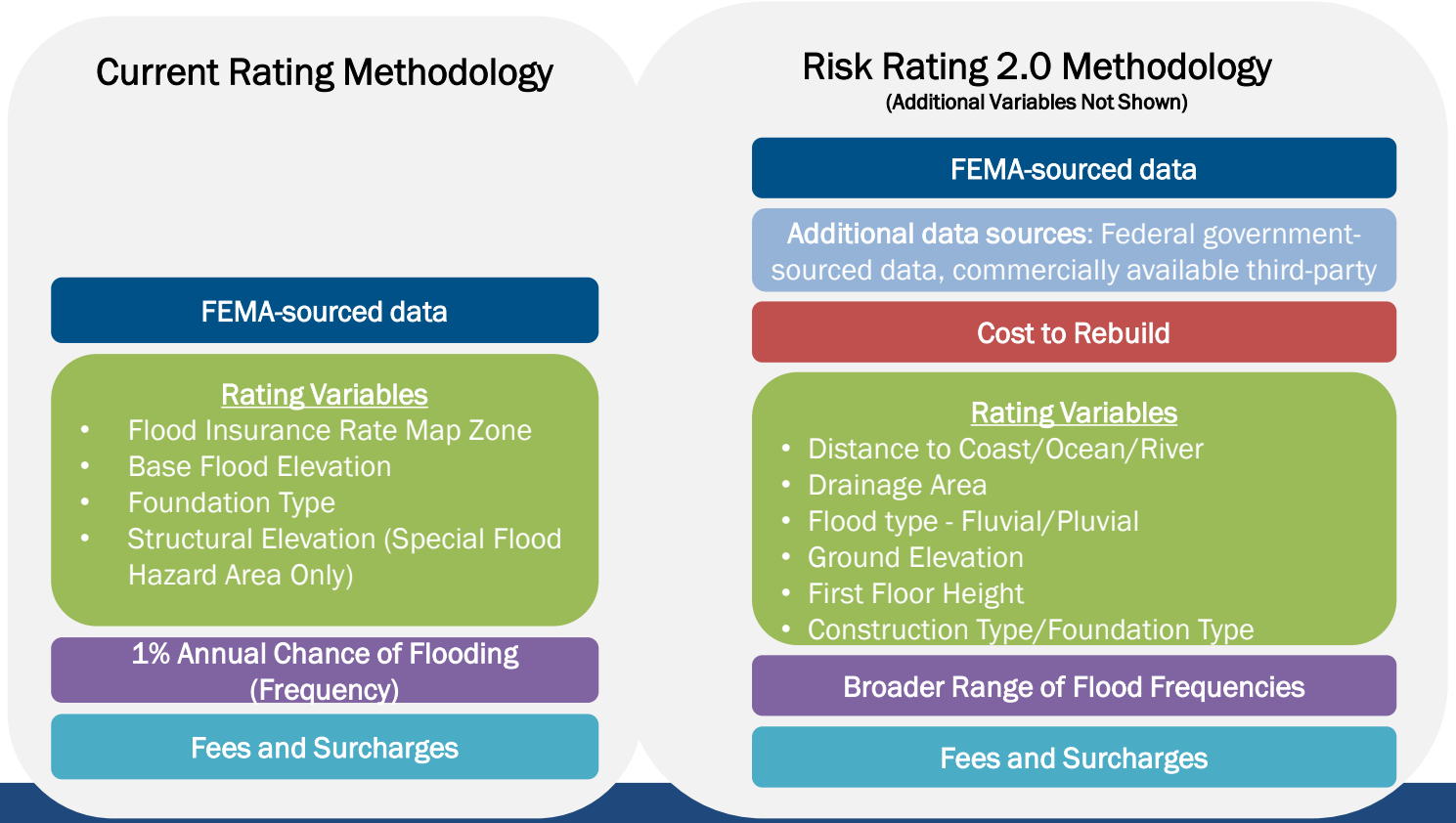
Mexico Beach Flood Maps and Hurricane Michael Damage

BEFORE

AFTER

NFIP Transformation (cont'd)

Risk Rating 2.0 premiums will more accurately reflect flood risk by considering a broader range of variables.



Recommended Take-Aways for Actuaries

FEMA

- Try to Retain Skills from your Advanced Ratemaking Exam.
- Learn about GLM's, from exams, self-teaching, or other sources.
- Get yourself up-to-date in statistical learning methods, through the CAS or through outside learning.
- Familiarize yourself with the assumptions and the outputs of modern catastrophe models.
- If you work in Property Insurance (esp. Property CAT), learn about GIS mapping.

CoreLogic®

Building a Complete Flood Insurance Program

Underwriting and Risk Management

March 24, 2020 | **Howard A. Kunst, FCAS MAAA CCRMP**

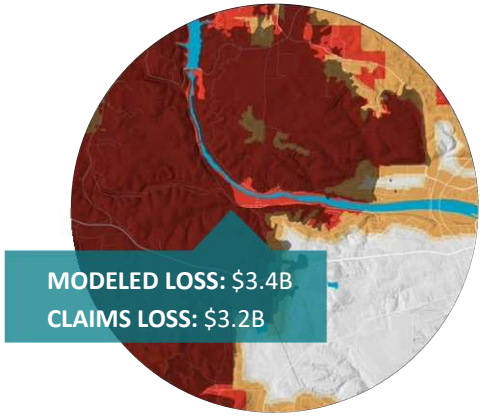
Agenda

- Different types of natural catastrophe models
- How models may be used to assist with underwriting and risk selection
- Using the models to understand portfolio risk management

Types of Natural Catastrophe Models

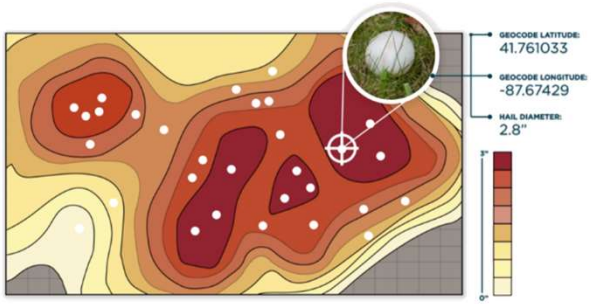
DETERMINISTIC

What could happen?



PROBABILISTIC

What if it happened?



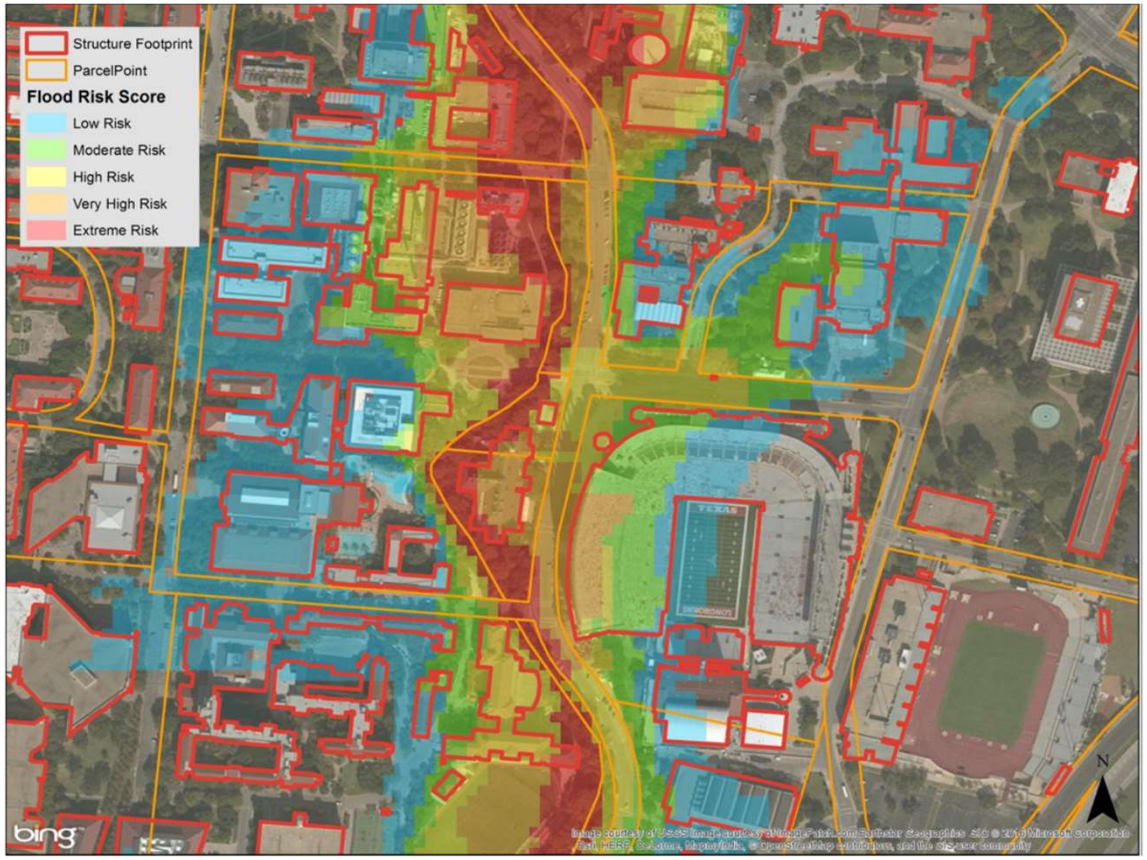
FORENSIC

What did happen?

Underwriting Considerations

Using Deterministic Models in Underwriting

- Risk selection is important to consider along with proper rates (based on exposure to risk)
  - Hazard risk scores provide a good representation of relative risk



Underwriting Considerations

Using Deterministic Models in Underwriting

- Use to set thresholds/underwriting rules
- Scores can be easily implemented/imported into U/W work stream, particularly for homogenous lines of business
- Understand nuances in the rating structure
- Inability to charge actuarially sound rates due to regulation

Underwriting Considerations

Using Probabilistic Models in Underwriting

- More complicated risks (e.g. larger, commercial structures) may require more information
- EP curve considerations (impacts of tail events)
- Aggregation of risk
- Impact on reinsurance / capital management
  - Correlations to current book

Risk Management Considerations

Using Natural Catastrophe Models

- Deterministic Risk Scores provide a method to look at the distribution of risk across various geographies
  - Compare risk exposure distribution for a company vs industry total exposures
- Probabilistic model results have many uses in managing exposures to catastrophe losses
  - AAL's and PML's provide necessary information for senior management to make a number of financial decisions
  - Aggregations / Reinsurance
  - Scenario testing
  - Capital allocation (AAL's, PML's, Tvar)

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Thank you