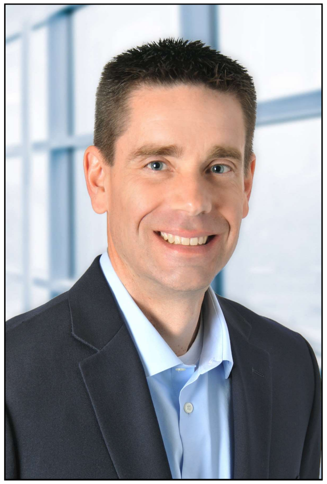
SPRING MEETING

MAY 11-13, 2020 • ONLINE EVENT

Flood Insurance in the Private Sector

Presenters



- **Greg Frankowiak,** FCAS, MAAA, CSPA, CPCU, MSM
- Pinnacle Actuarial Resources, Inc.
- Senior Consulting Actuary
- Bloomington, Illinois

- **Megan Hart,** PhD
- Aon
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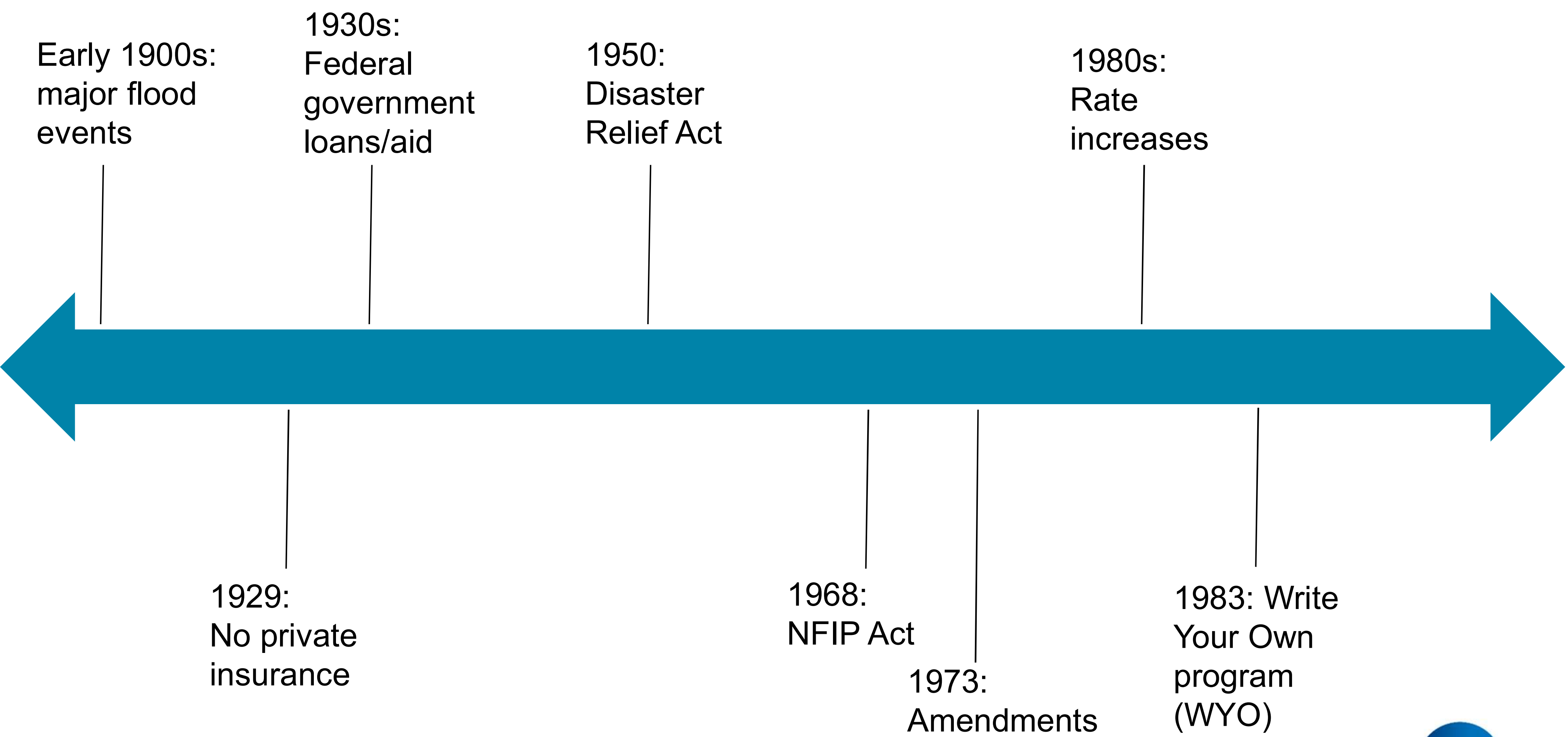
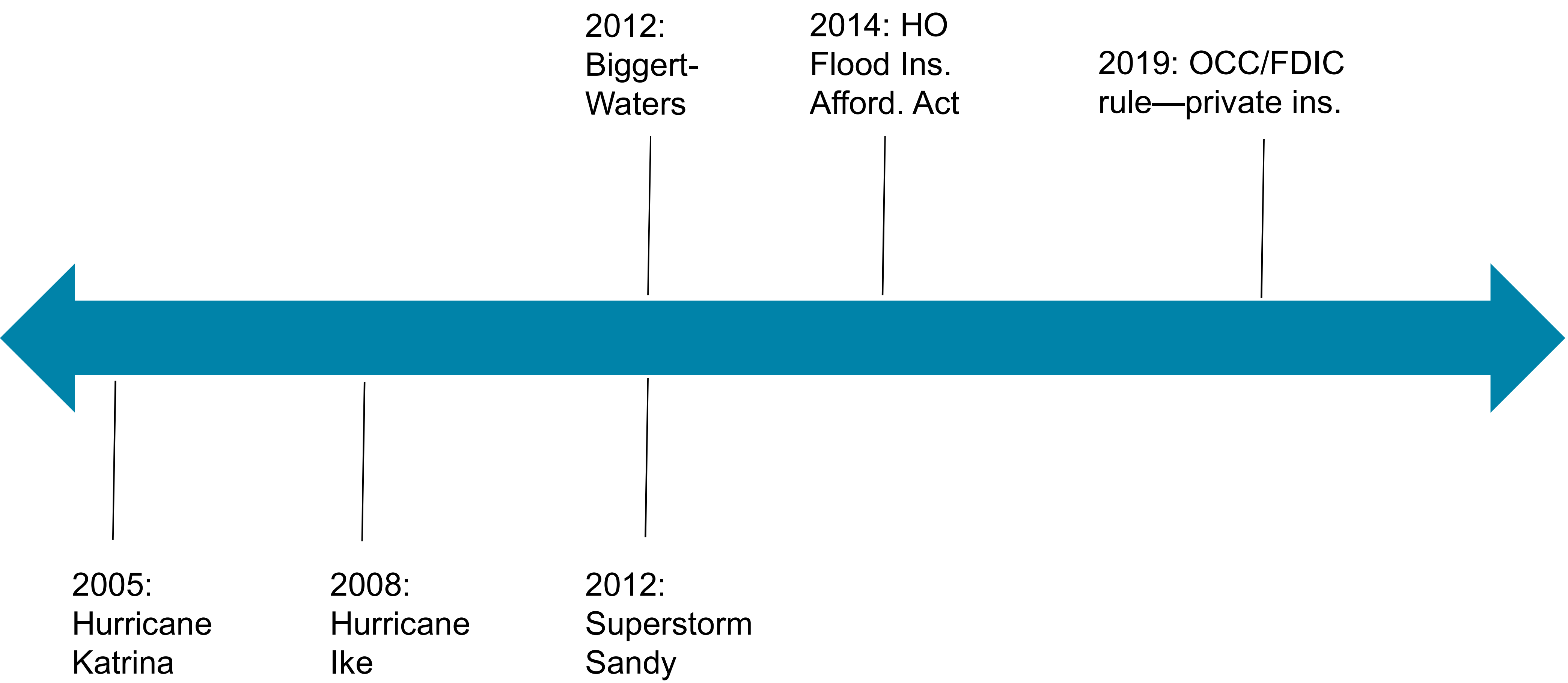
- Southfield, Michigan

Current Landscape of the Privatization of Flood Insurance

Flood - History



Flood - History



National Flood Insurance Program (NFIP)

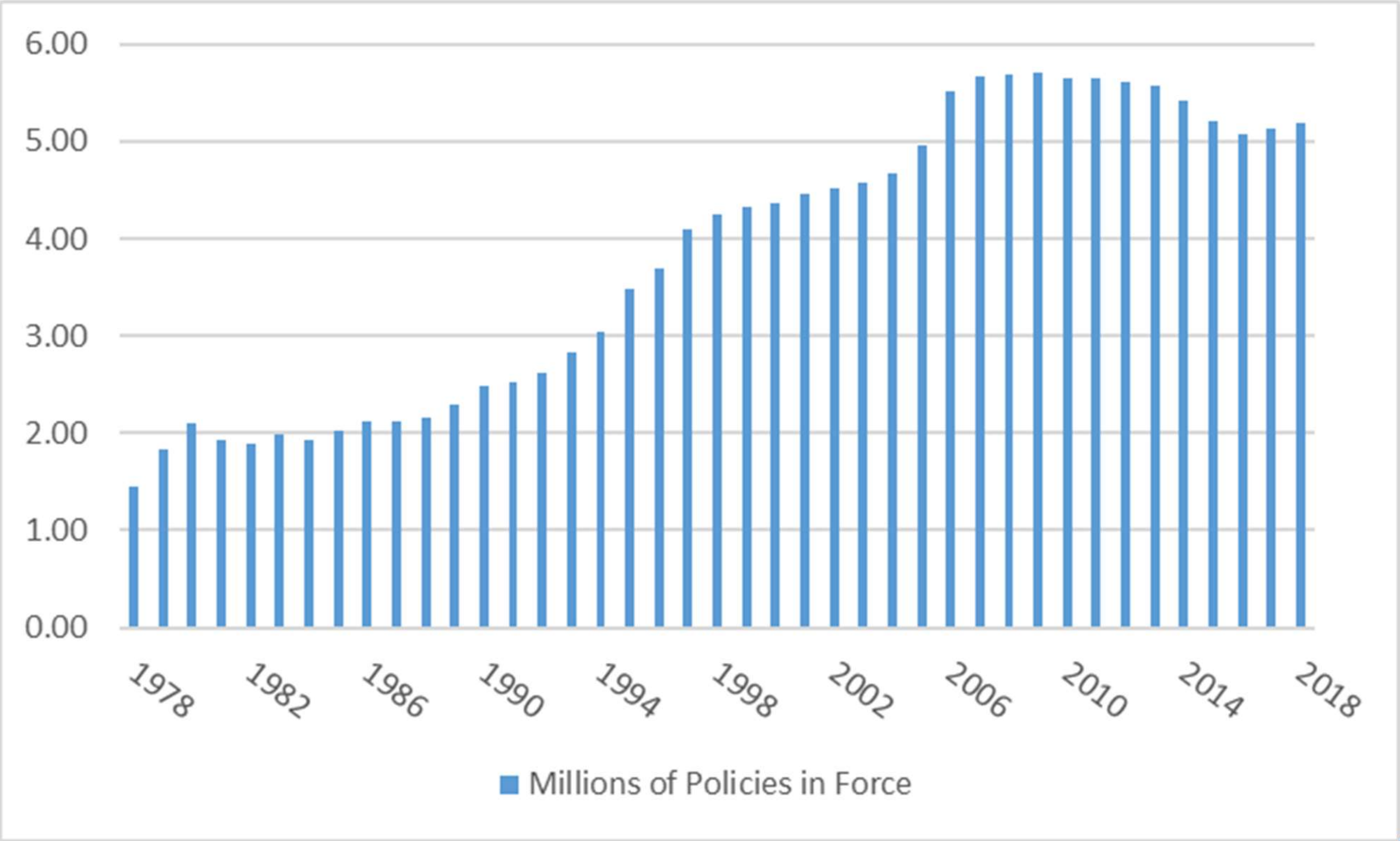
Program formed to

- address lack of coverage offered in private insurance market
- reflect limited tools to assess risk
- address problem of adverse selection

NATIONAL FLOOD INSURANCE PROGRAM

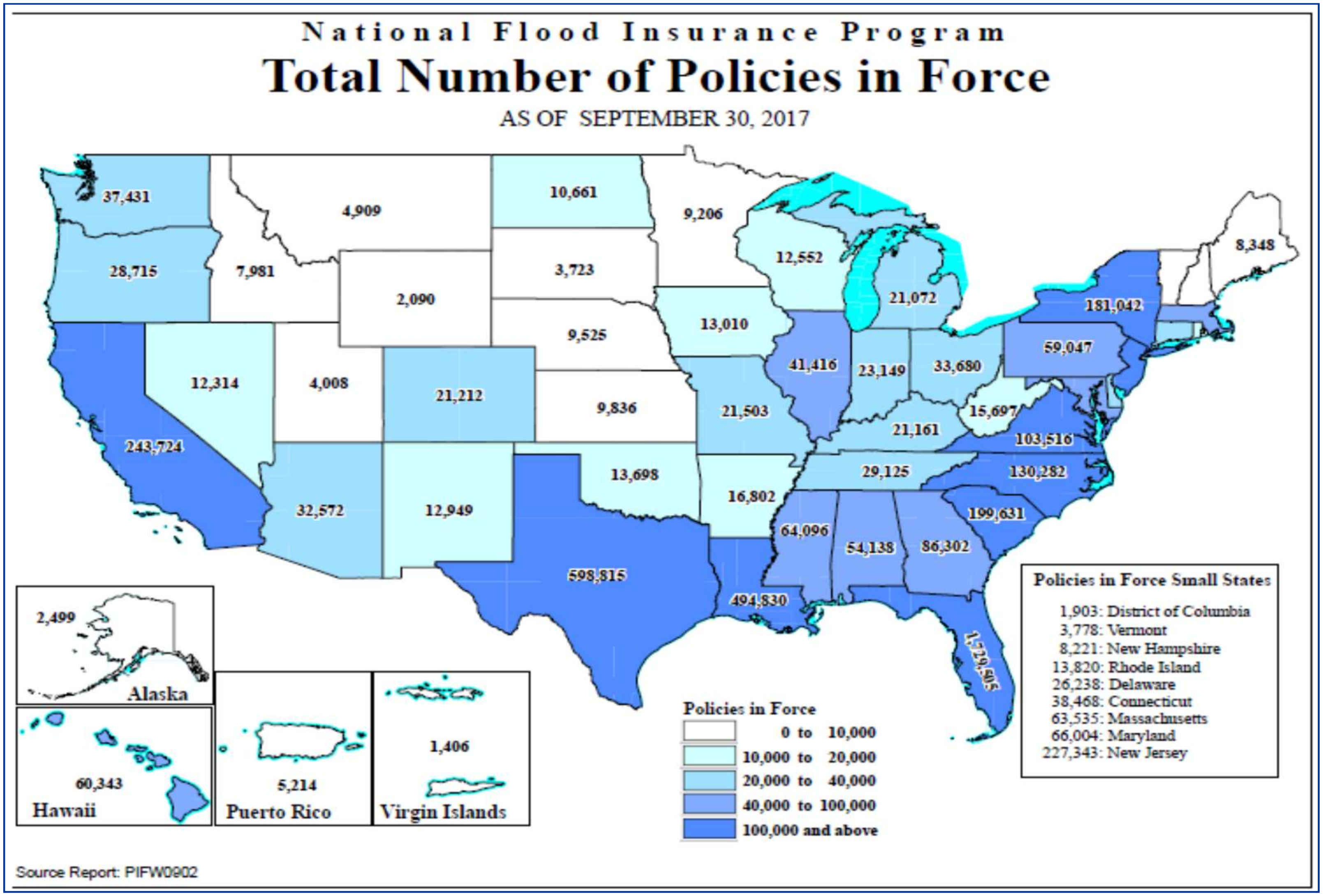
FEMA

NFIP – Policies in Force by Calendar Year



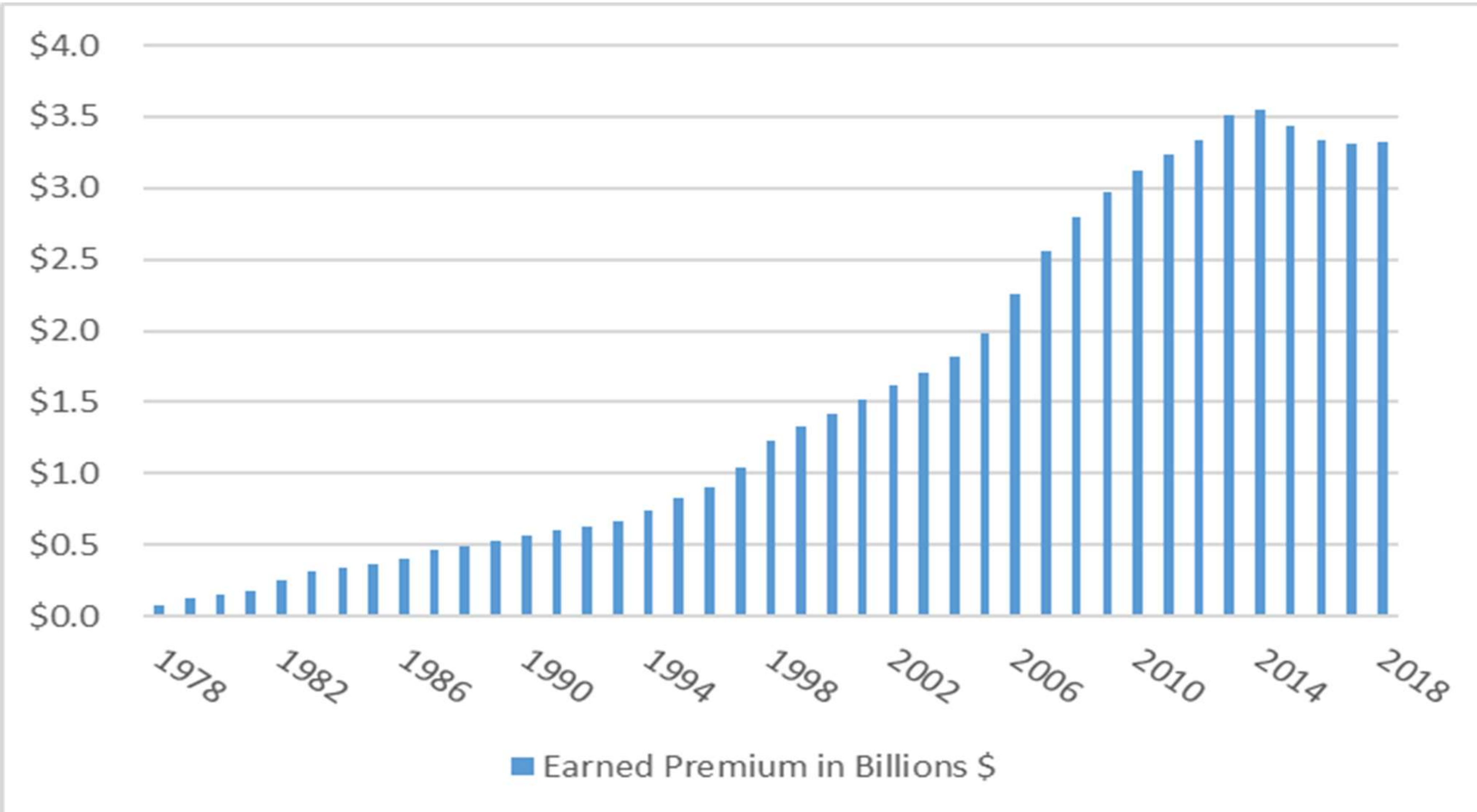
Source: fema.gov

Flood—NFIP



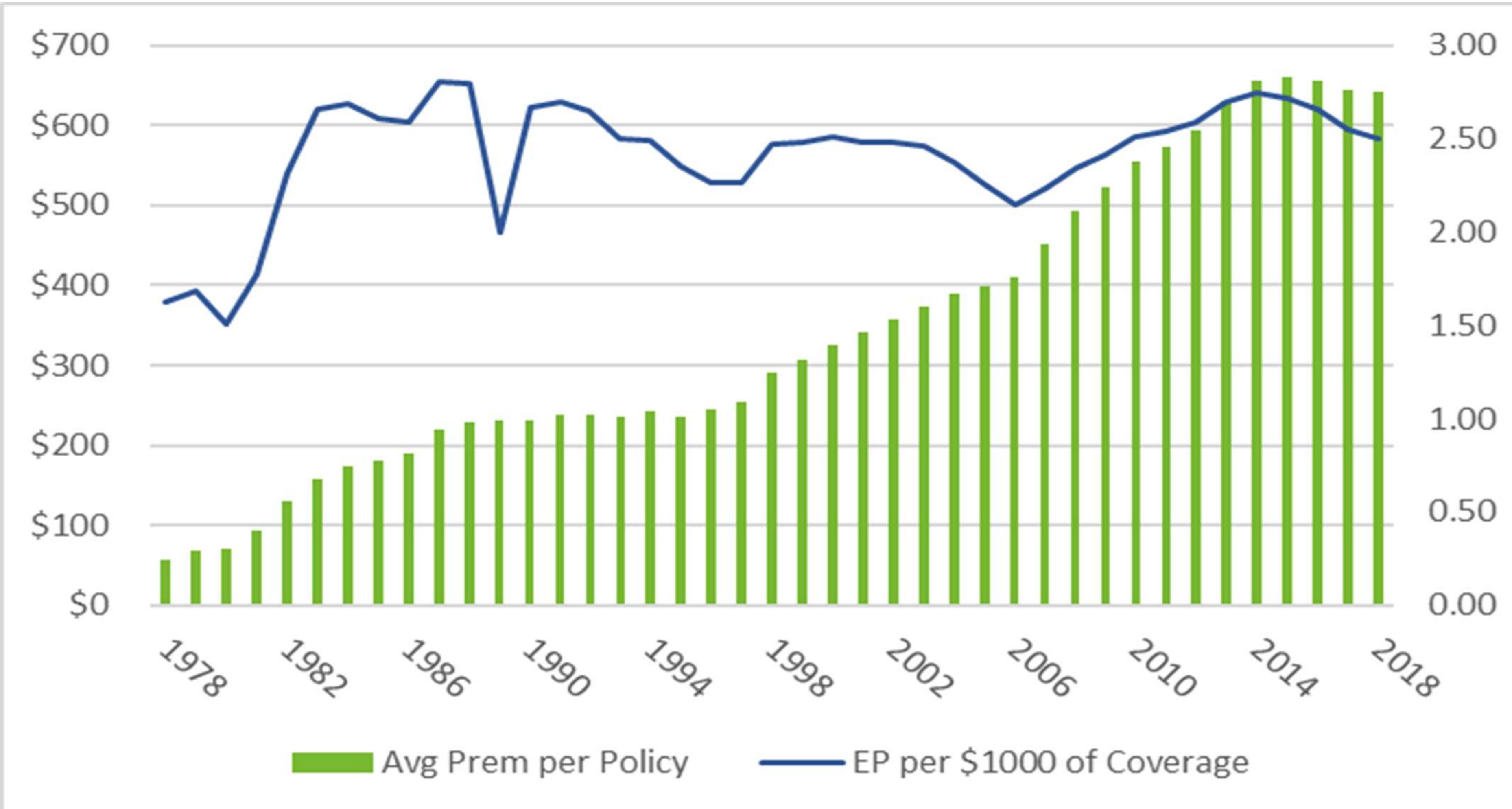
Source: fema.gov

NFIP – Earned Premium by Calendar Year



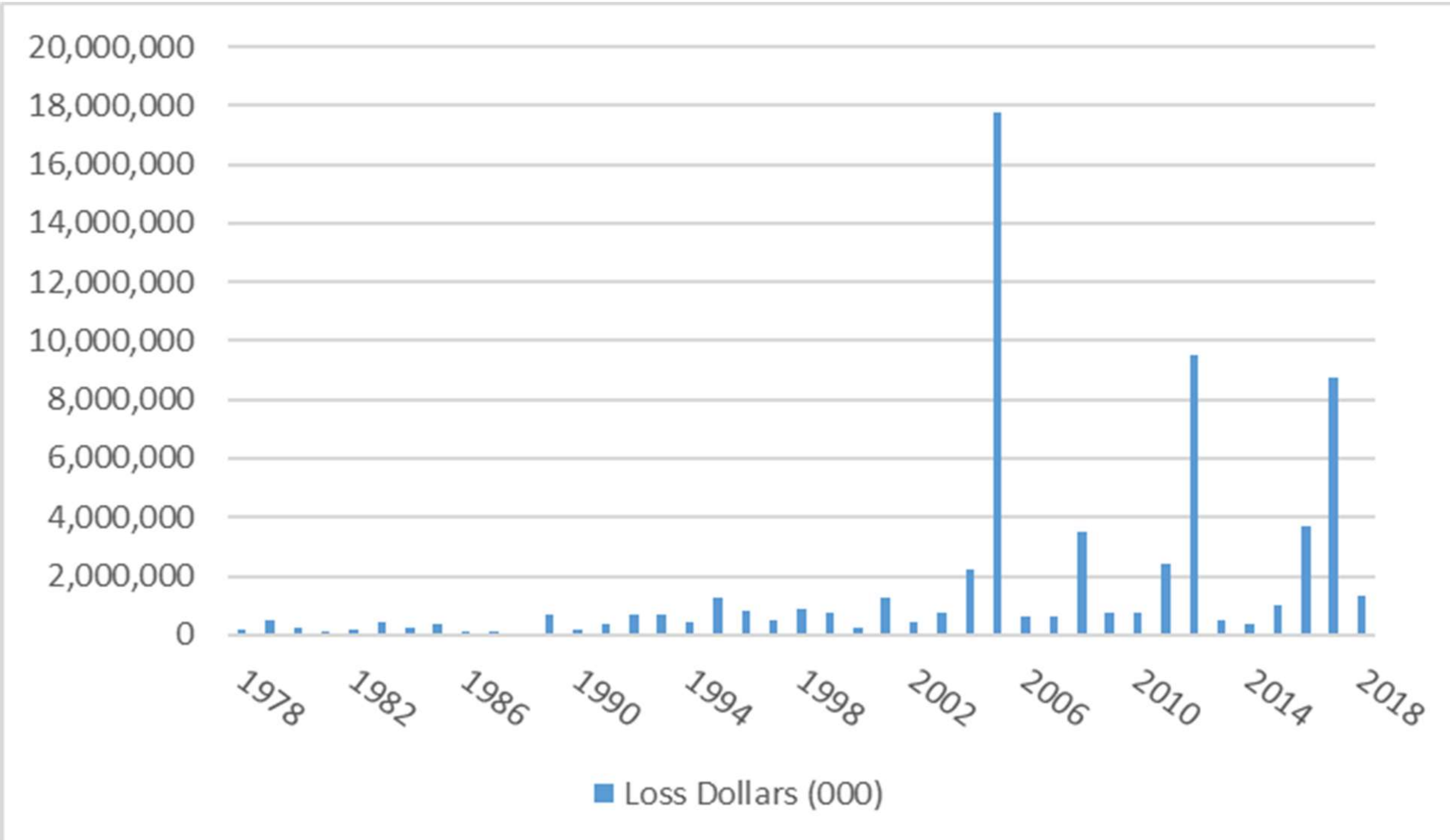
Source: fema.gov

NFIP – Premium Measures by Calendar Year



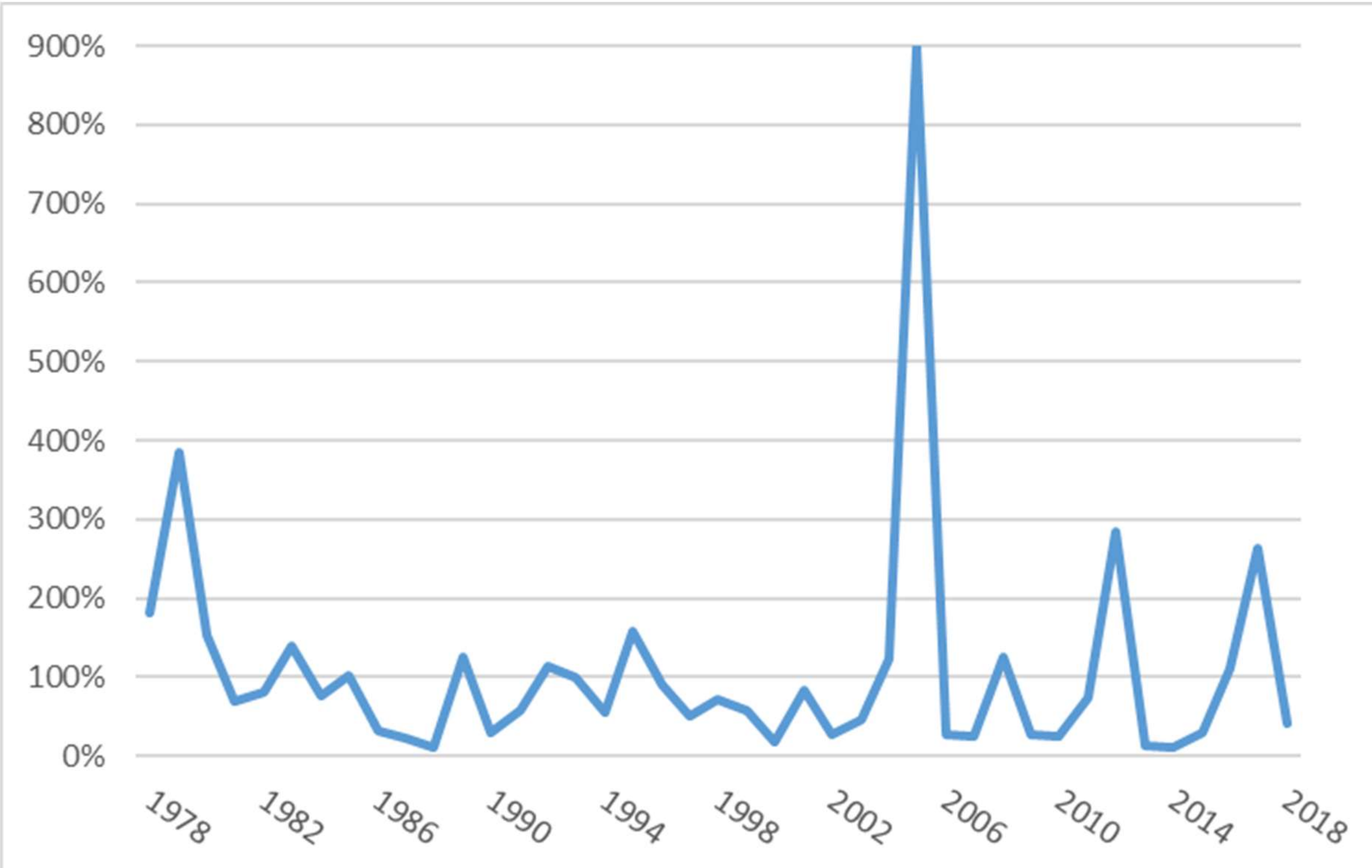
Source: fema.gov

NFIP – Calendar Year Losses Paid



Source: fema.gov

NFIP – Calendar Year Loss Ratios



Source: fema.gov

According to the NAIC in 2018:

- Approx. $644 million of direct written premium in US
- About 15% of the total flood insurance market
- 120 companies writing private coverage
- CA, FL, LA, NJ, NY, PA, PR, TX each had $20 million+ of private flood insurance direct written premium
  - Nearly 60% of total private flood insurance market

According to Insurance Information Institute (III):

- 15% of American homeowners had a flood insurance policy in 2018
- Possible reasons for low take-up rate:
  - Too expensive
  - Homeowners not aware they don’t have coverage
  - Underestimation of risk of flooding
- Opportunity for growth in the US!

Polling Question!

Based on 2018 Written Premium

Top US Private Flood Insurer (Comm. + Res.):

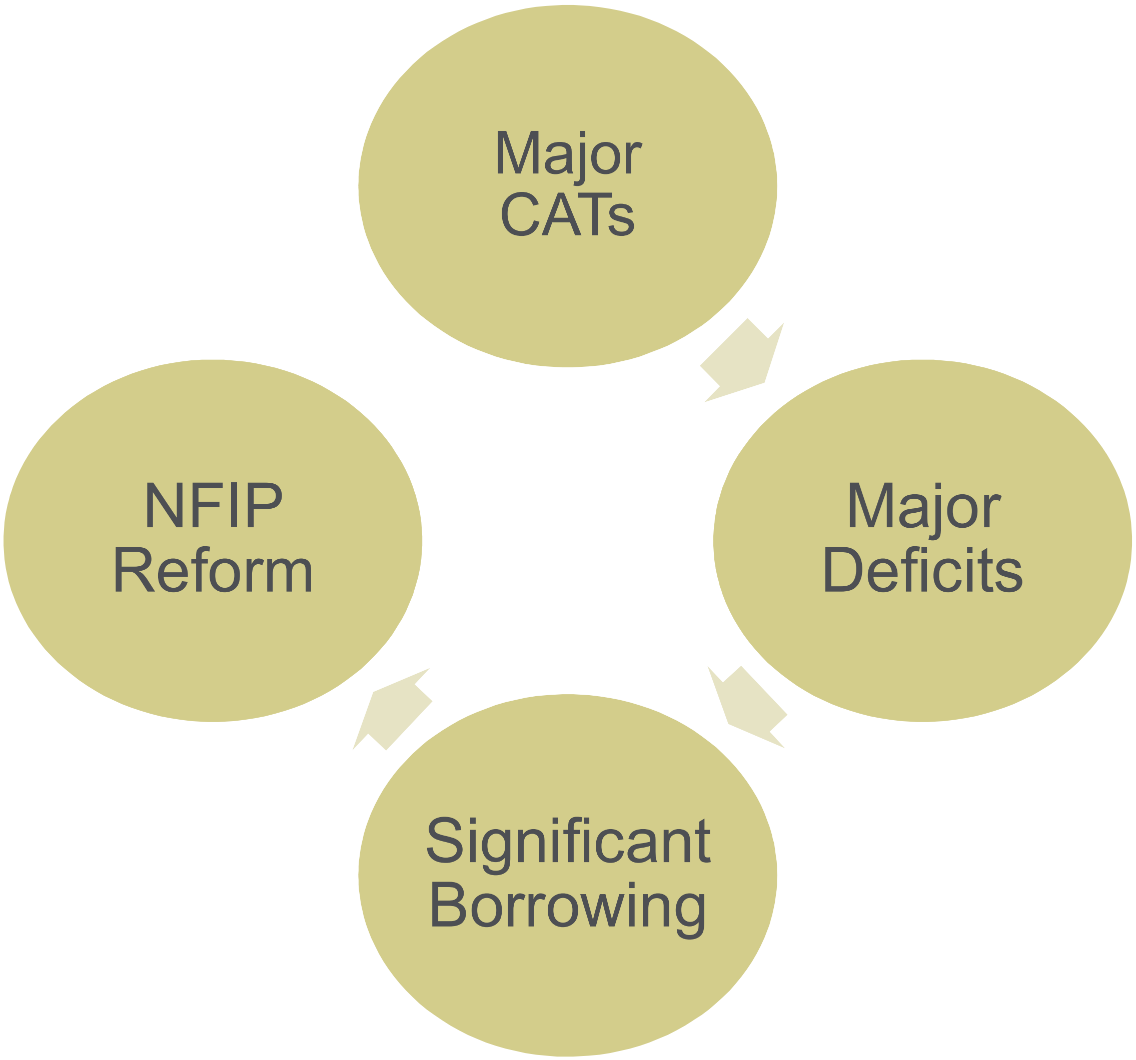
A: AIG

B: FM Global

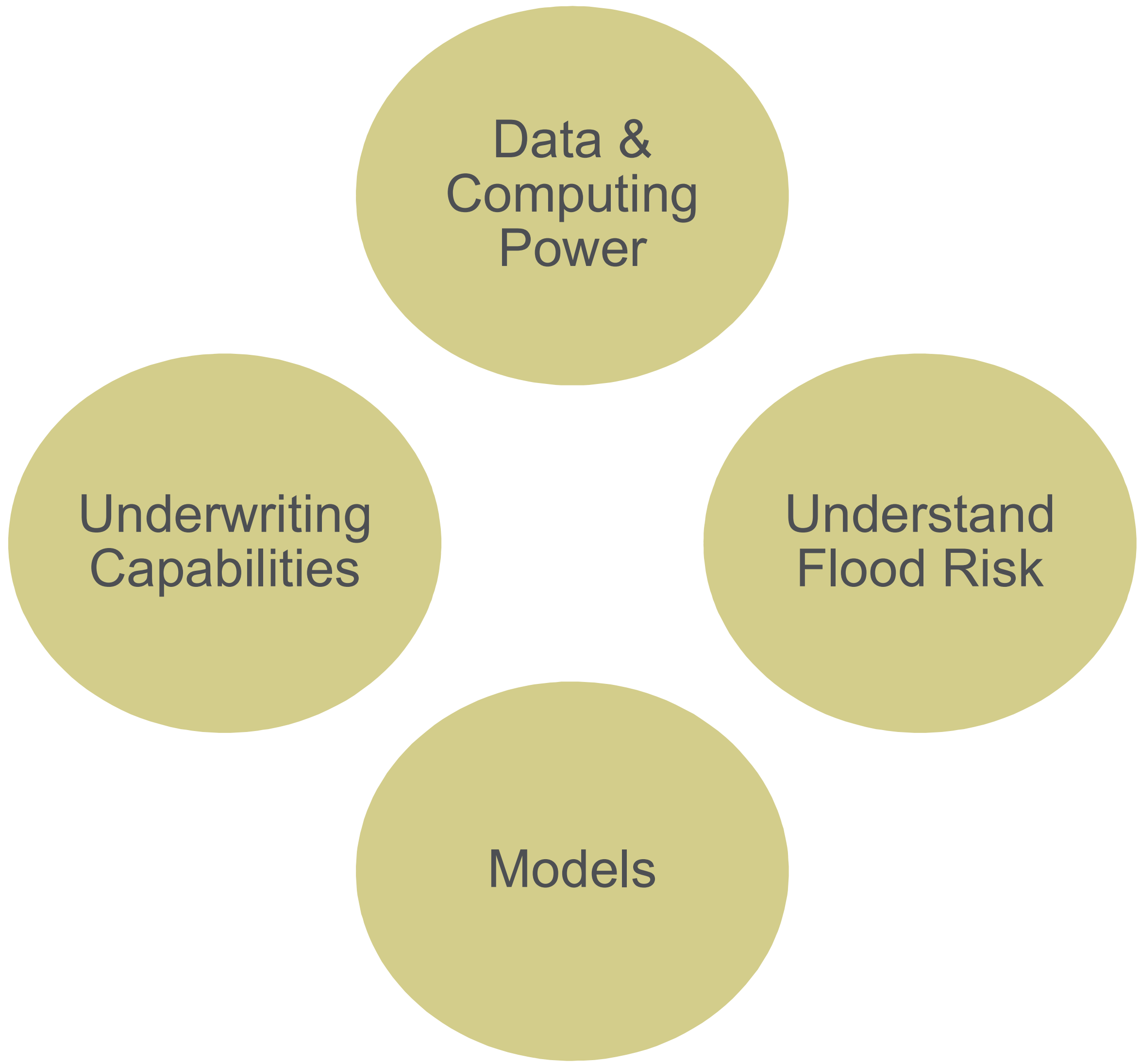
C: Swiss Re

D: Allianz

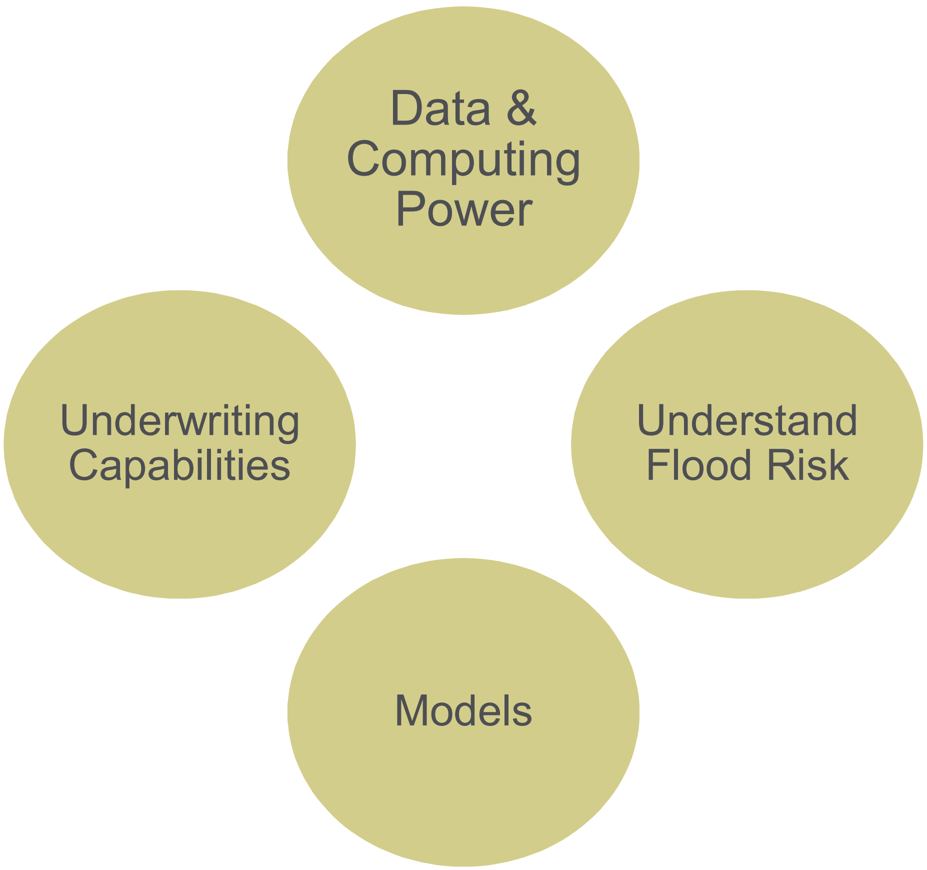
NFIP Evolution & Private Insurance Drivers



NFIP Evolution & Private Insurance Drivers

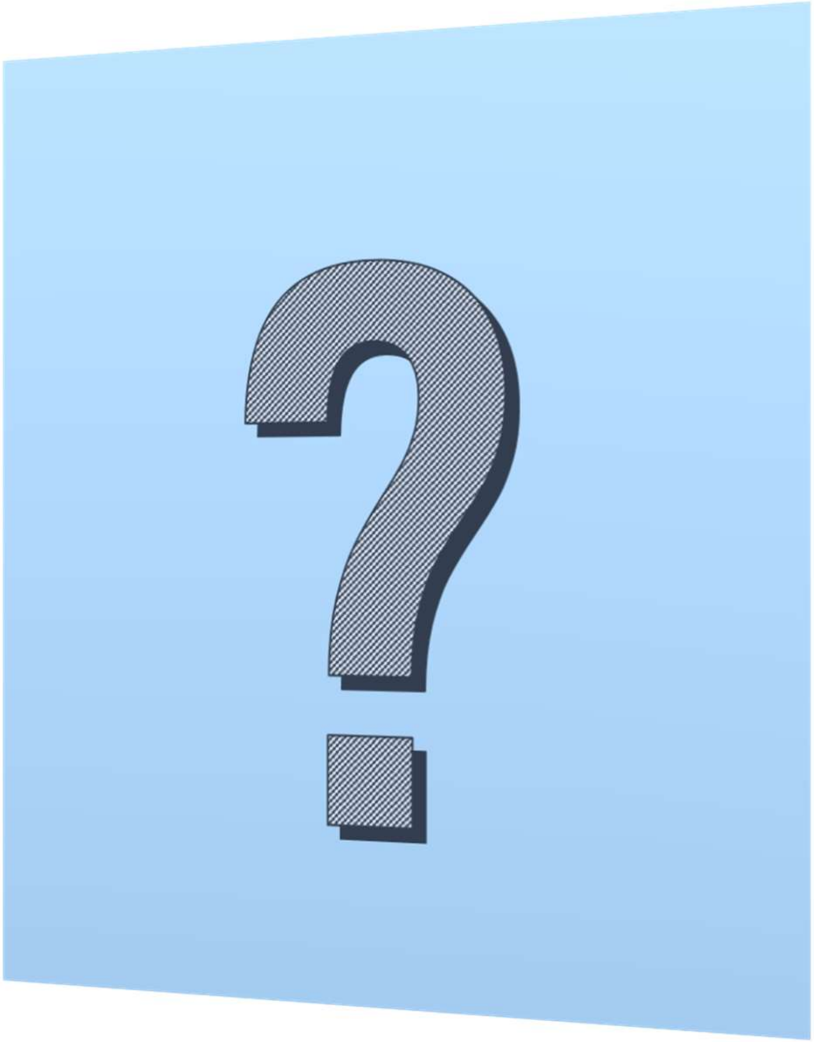


NFIP Evolution & Private Insurance Drivers



- Increased reinsurance capacity
- Likely improve willingness of private insurers to underwrite coverage

Private Flood Insurance - Key Considerations



Private Flood Insurance - Benefits

Private Flood Insurance - Uncertainties

Quantification of Flood Risk Using Catastrophe Models

Polling Question!

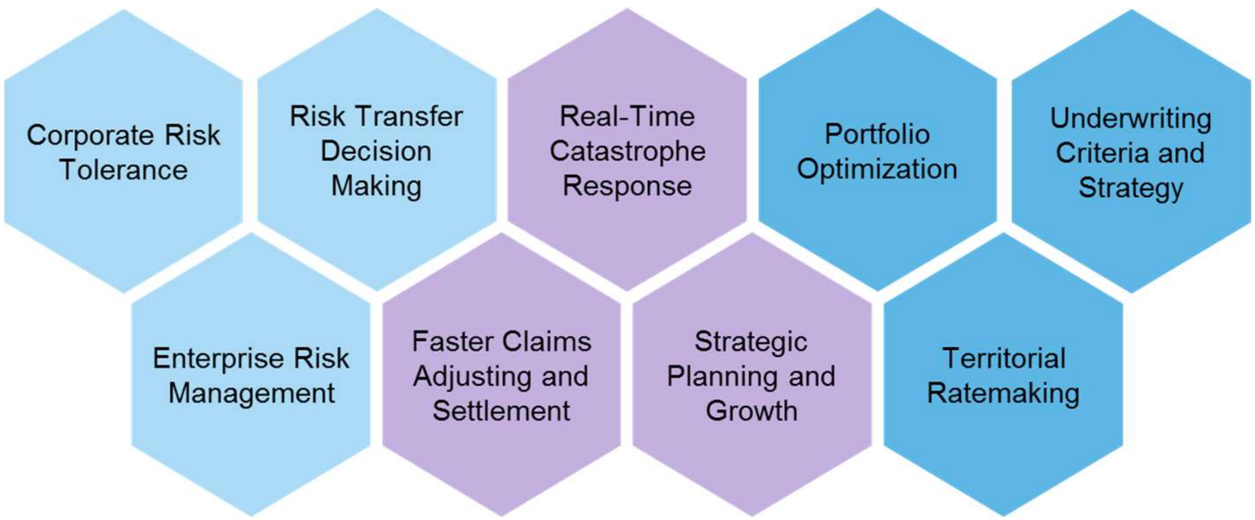
How often do you use a catastrophe model or catastrophe model output in your job (not necessarily a flood model)?

- A: Never
- B: Once or twice a year
- C: Monthly
- D: Weekly / Daily

Why Catastrophe Models?

Companies looking to make better business decisions and manage their catastrophe risk more effectively cannot rely on scarce historical loss data to project future losses

- Catastrophe occurrences are rare and/or data is limited
- Population growth and infrastructure development alter the risk landscape
- Catastrophe occurrences cause large loss over a wide area; models are a tool to manage accumulation of risk
- Catastrophe models provide a means to understand plausible scenarios that have not occurred in recent history



Sources of Flood

Fluvial (Riverine) Flooding

- Heavy rainfall or snow melt that causes water levels in rivers or creeks to overtop the banks

Source: *floodlist.com*

Pluvial (Flash) Flooding

- Heavy downpour of rain that saturates the urban drainage system and excess water cannot be absorbed

Storm Surge

- Rising coastal flood water due to a hurricane

Hurricane Harvey (cnn.com)

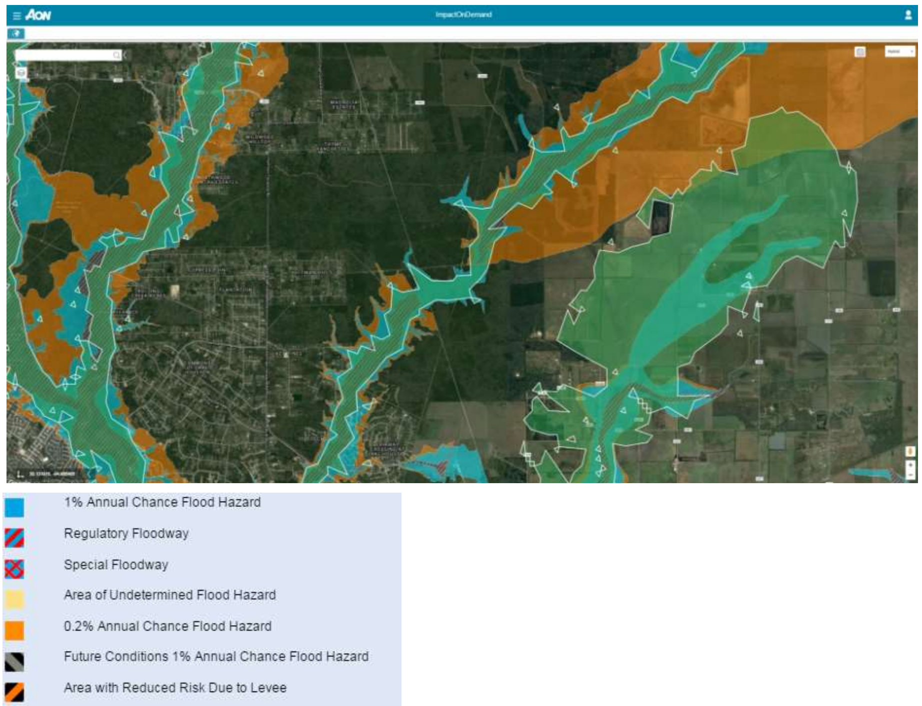
Hurricane-Induced Precipitation Flooding

- Flooding from rainfall associated with a tropical storm or hurricane

Why Flood Models?

Texas Inland Flooding – April 2016

Event shape compared to FEMA flood zones



- Recent events have proven the inadequacy of many of the FEMA flood zone classifications, this creates:
  - Potential for uninsured exposure for policyholders
  - Claims leakage post-event
  - Gaps in reinsurance protections depending on underwriting guidelines

Hurricane Michael

FEMA flood zones compared to High Water Marks

- Utilization of improved analytics offers opportunities to:
  - Educate policyholders
  - Expand and differentiate product offerings
  - Manage portfolio aggregations

The Role of the Catastrophe Model – Loss Metrics

Catastrophe models provide a holistic view of portfolio cat risk at various risk tolerance thresholds, while accounting for thousands of plausible scenarios that haven't been observed in the historical record

Return Period	Model A	Model B
1000	2,552	2,476
500	1,666	1,615
250	1,153	1,112
200	938	917
100	570	548
50	276	269
20	97	93
AAL	49	48
Std Dev	165	160

Gross OEP in Millions
LOB: All; Peril: All

Average Annual Loss

Measure of overall catastrophe risk, function of both severity and frequency of losses

On average, you can expect to incur $48M of catastrophe loss in a given year

Probable Maximum Loss (PML) or Return Period Loss

An estimate of the likelihood that a catastrophic loss will be met or exceeded

The 100 yr return period is $548M – There is a 1% probability of having a loss of $548M or greater

Occurrence Exceedance Probability (OEP)

Probability that the single largest event loss in a year will exceed a loss threshold

Aggregate Exceedance Probability (AEP)

Probability that the aggregate event losses in a year will exceed a loss threshold

Volatility

Mean losses will fluctuate from year to year

Volatility measures the amount of fluctuation

Measurement: CV = Standard Deviation ÷ Average Annual Loss

History of Flood Models

Storm Surge: Model Introductions and Major Hazard Methodology Updates

1990s
- Storm surge first included in HU model (simple parametric approaches) — AIR, RMS — 1997

2000s
- CoreLogic incorporates storm surge (simple parametric approach) — CoreLogic — 2007
- Impact Forecasting incorporates SLOSH model — 2007

2010s
- RMS upgraded model to Mike 21 — RMS — 2011
- AIR upgraded model to SLOSH — AIR — 2015
- KatRisk storm surge model introduced — KatRisk — 2016
- KCC introduces storm surge model — KC &CO

Inland Flood: Model Introductions and Major Hazard Methodology Updates

2000s
- Impact Forecasting introduces riverine model — 2007

2010s
- AIR introduces inland flood model — AIR — 2015
- CoreLogic and KatRisk portfolio models introduced — KatRisk, CoreLogic — 2016
- Impact Forecasting incorporates flash flooding — 2016
- RMS introduces inland flood model on HD platform — RMS — 2018
- Fathom inland flood model released — 2019 — FATHOM

Polling Question!

If you use catastrophe models and anticipate using a flood model in the future, how would you use the model?

- A: Underwriting Criteria
- B: Strategic Planning and Growth
- C: Risk Transfer Decision Making
- D: More than one of the above
- E: Other (please write in)

Evaluating Flood Models

Components of a Catastrophe Model

Hazard
Event Generation

Where?
How Big?
How Often?

Hazard
Local Intensity

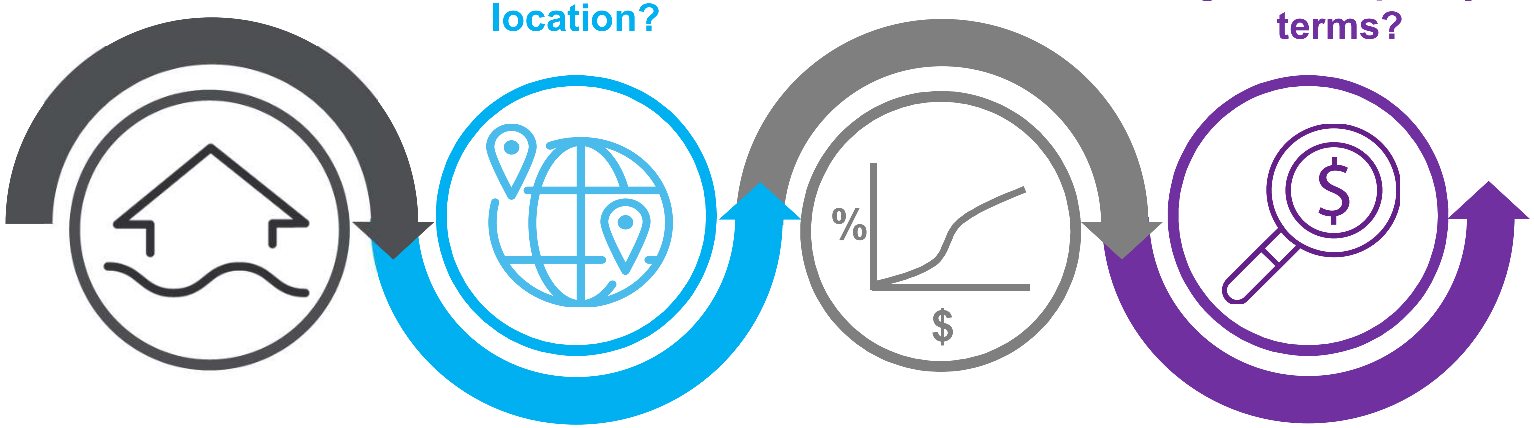
What is the intensity of the event for a location?

Vulnerability
Damage Estimation

What is the damage to a location?

Financial
Insured Loss Calculation

How does the damage get paid given the policy terms?



- Methodology
- Event definition
- Frequency
- Intensity
- Hazard parameters

- Footprint definition
- Local site conditions
  - Elevation
  - Slope
  - Land Use

- Consider:
  - Risk characteristics
  - Coverage type
  - Geography
- Supported by:
  - Claims
  - Engineering judgment

- Limits
- Deductibles
- Reinsurance

What Does Model Evaluation Entail?

All components of a catastrophe model from hazard and vulnerability to losses are evaluated to identify model strengths and concerns, with the ultimate goal of helping clients choose a best-fit solution based on their portfolio and risk management goals

Hazard

- Are event frequency/severity relationships reasonable?
- Are current scientific methods used to create event footprints?

Vulnerability

- Are relationships between risk characteristics and vulnerability regions reasonable?
- How are relationships between hazard and damage derived? Are they defendable?

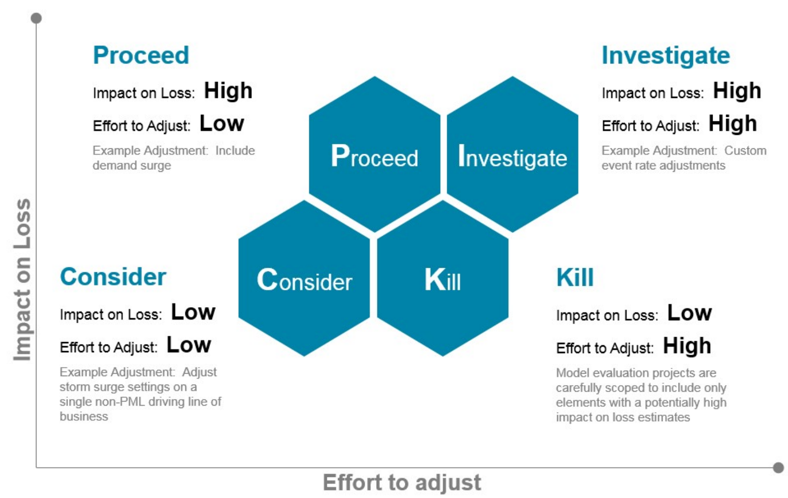
Losses

- Is loss distributed appropriately across geographic regions?
- How do different types of events contribute to loss along the EP curve?
- Where are key historical event losses positioned on the EP curve?

Consider Model Adjustments

Model adjustments can be used to address model concerns based on **claims data**, identified sources of **non-modeled loss**, or **risk tolerance**

The **PICK decision matrix** helps clients decide whether further adjustments to the model should be made based on **loss impact** and **effort to adjust** the model



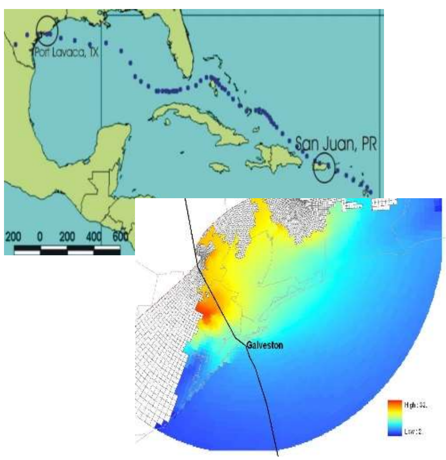
Hazard: Methodology

Storm Surge

Inland Flood

Hurricane Tracks
- Stochastic events from the hurricane models

Hazard Model
- Changes in hazard parameters along the length of the track
- Bathymetry



Hydrology
- Precipitation data is used to create stochastic events
- Rainfall runoff is determined considering factors such as soil, elevation, and land use

Hydraulics
- Rainfall runoff is routed through drainage basins and into the river network; Converted to a flood depth

Flood Depth
- Surge / Flood depth stored in hazard grid
- Compared with ground elevation grid
- Building elevation also considered

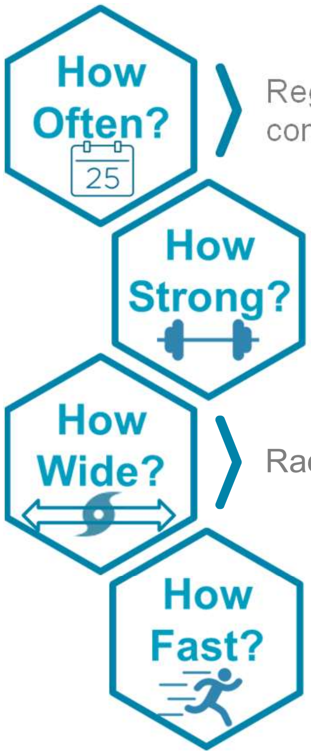
Damage
- Differentiation in vulnerability varies by model
- Key characteristics include story height, year built, construction and foundation type

Picture from NBC.com

Evaluating Storm Surge Hazard Approaches

Evaluation of storm surge hazard involves a two-fold approach of evaluating the driving hurricane wind model in addition to evaluating the storm surge model itself

Evaluating a Hurricane Model

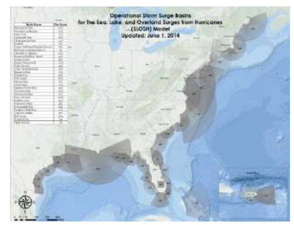


- How Often? Regional landfall rates by category compared to historical
- How Strong? Central pressure and one-minute sustained wind speed (Vmax)
- How Wide? Radius of maximum winds (Rmax)
- How Fast? Forward speed

Different Storm Surge Model Types

Parametric Model

- Height of water on land is modeled analytically given a few key inputs such as distance to coast, elevation, land cover, height of water at the coast, etc.



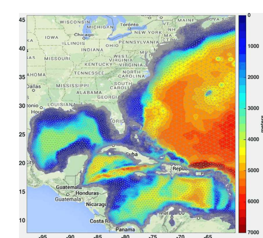
Orthogonal curvilinear regional meshes in the SLOSH model

Simplified Numerical Model: SLOSH

- SLOSH is a simplified numerical model developed by the National Weather Service (NWS) that utilizes orthogonal curvilinear regional meshes to force coastal flooding on land
  - An internal wind model is used to solve for meteorological forcing
  - Simplified versions of shallow water equations used

Fully Hydrodynamic Models: MIKE 21 & ADCIRC

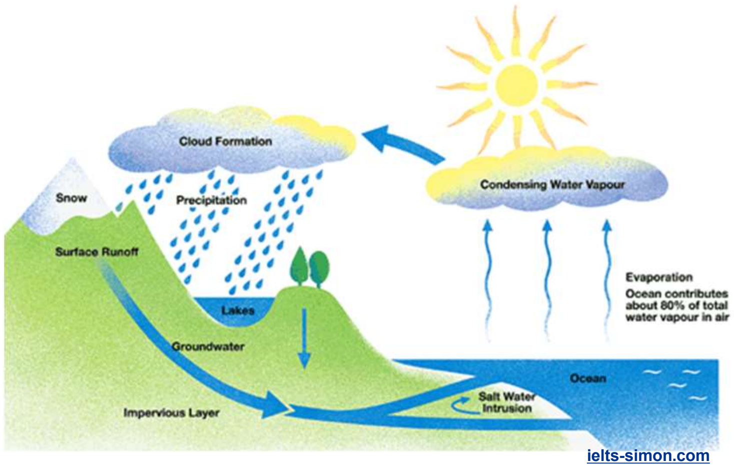
- 2D hydrodynamic models that use unstructured triangular regional meshes to estimate storm surge inundation
  - Use shallow water equations to simulate hydrodynamics associated with a hurricane
  - Use high-resolution topography, bathymetry, and land use data as well as a wind model to solve for meteorological forcing



ADCIRC

Evaluating Inland Flood Hazard Approaches

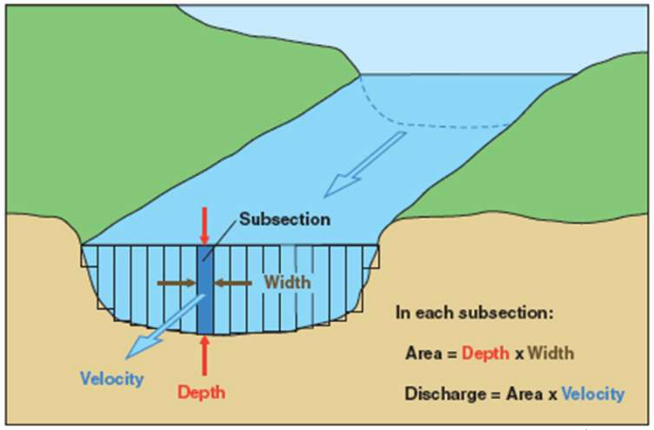
Hydrologic Cycle



ielts-simon.com

- Event generation (both on-plain and off-plain)?
  - GCM vs. Gauge Data
  - Event definition
  - Consideration of snowmelt
- Data sources and vintage; Resolution
- Surface runoff – How are discharges determined along the river network? How are off-plain flood footprints determined?

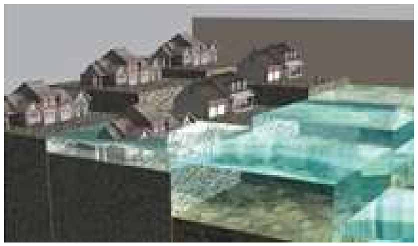
Flood Routing & Hydraulic Modeling



tes.com

- Flood routing approach employed
- Distances between cross sections for determining discharge along river network
- Resolution of DTM used in hydraulic model for estimating flood depths

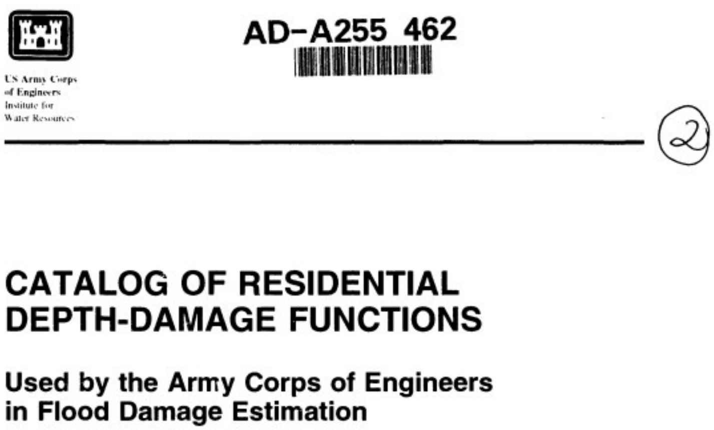
Flood Depth & Damage



Nature.org

Resolution of hazard grid and resolution of ground elevation

Validation of depths for historical events



US Army Corps of Engineers Institute for Water Resources

AD-A255 462

CATALOG OF RESIDENTIAL DEPTH-DAMAGE FUNCTIONS

Used by the Army Corps of Engineers in Flood Damage Estimation

Source and Approach:

- Component-based vs. Observation
- Army Corps of Engineers
- Institute of Water Resources
- Claims Data

Construction

Year Built

Occupancy

Stories

Primary risk characteristics supported

- Availability of key construction and occupancy classes

Supported secondary modifiers

Polling Question!

What do you think is the most important exposure input to a flood model for accurate risk assessment?

A: Number of Stories

B: Occupancy

C: First Floor Height

D: Construction Type

Key Vulnerability Inputs for Flood

First Floor Height

- Do the loss cost relativities make sense?
- What are the assumptions for unknown?
- Is there the ability to input user-defined first floor height?

Foundation Type

- What options are available?
- What is the impact of going from unknown to known?

Number of Stories

- Is this input supported in the flood model?
- Are the ompact by coverage as expected?

Construction Type

- Are the required construction classes available?
- Do the loss cost relativities make sense?

Year Built

- How implemented in the model?
- Is the impact as expected?

Occupancy

- Are the required occupancy classes available?
- Do the loss cost relativities make sense?

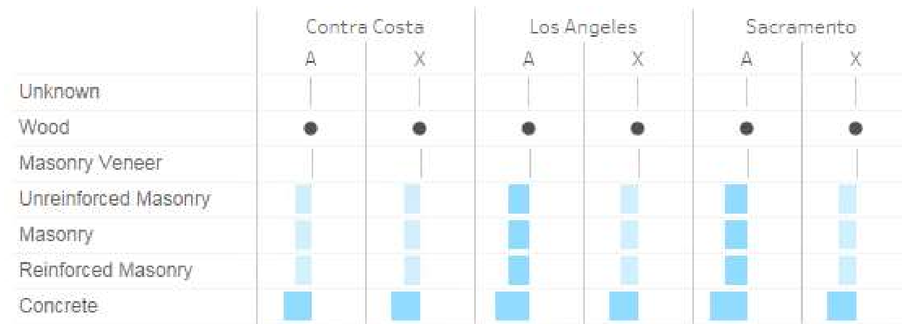
FFH Loss Cost Relative to 1 ft FFH

Single Family, Wood Frame, 1 Story, 2000 Year Built, Slab Foundation

	Contra Costa		Los Angeles		Sacramento	
	A	X	A	X	A	X
Unknown						
0	277%	220%	62%	145%	46%	149%
1	●	●	●	●	●	●
2	-100%	-95%	-49%	-94%		-88%
3	-100%	-100%	-83%	-100%	-71%	-96%
4	-100%	-100%	-97%	-100%	-90%	-100%

Construction Class Loss Cost Relative to Wood Frame

Single Family, 1 Story, 2000 Year Built, 1 ft First Floor Height, Slab Foundation

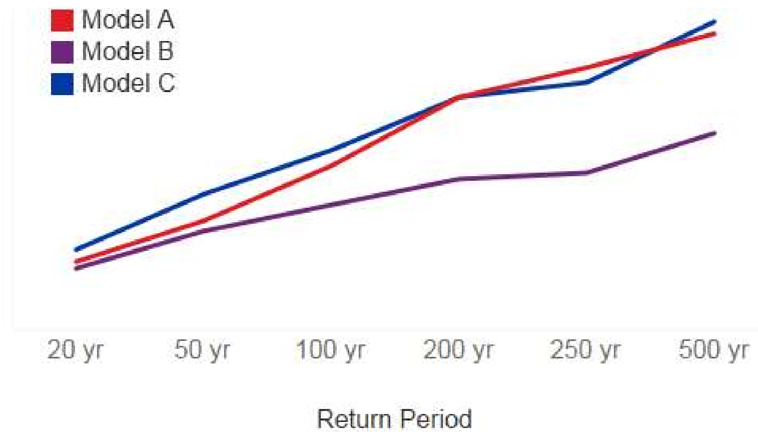


Modeled Loss Comparisons

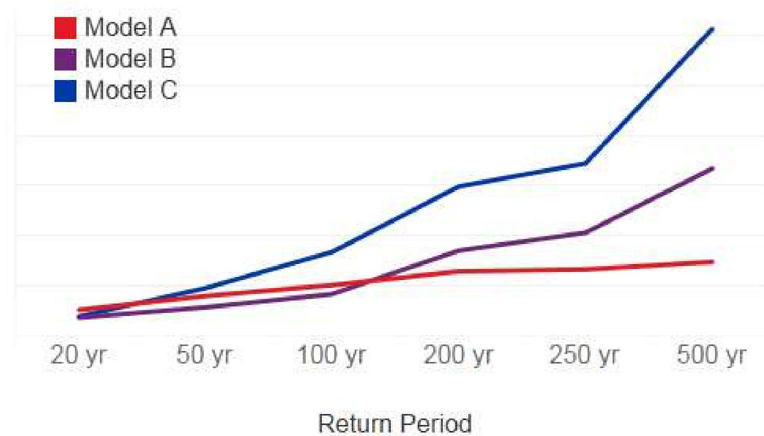
OEP Loss Comparisons

- OEP loss comparisons across models
- OEP vs AEP
- EP losses by Flood Zone
- Where do key historical events sit on the curve?

Zone A

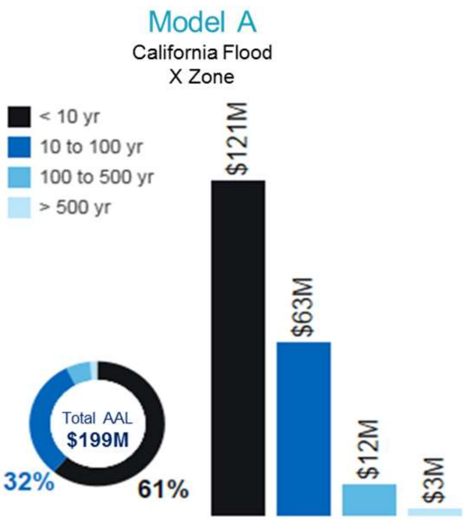


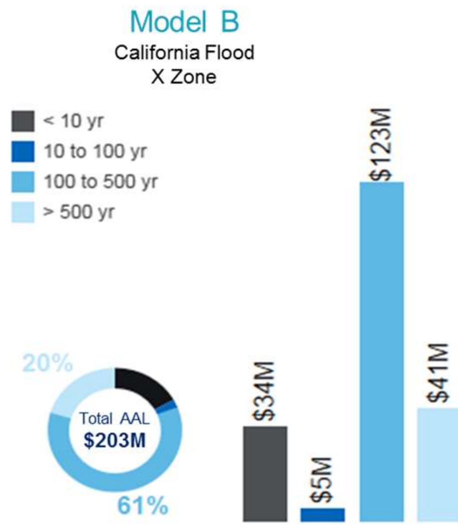
Zone X



Frequency Vs. Severity

AAL By Return Period

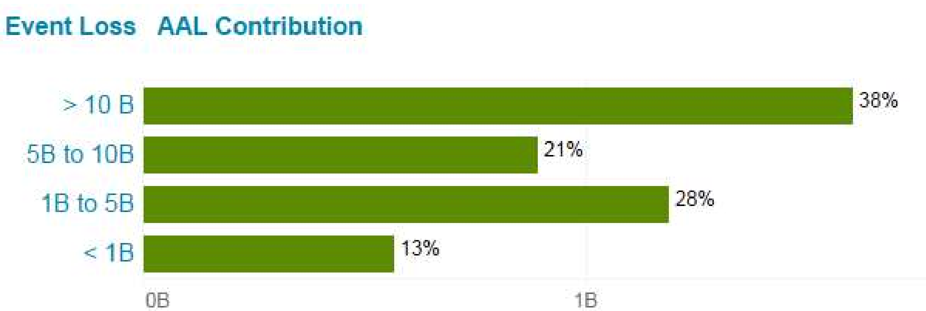




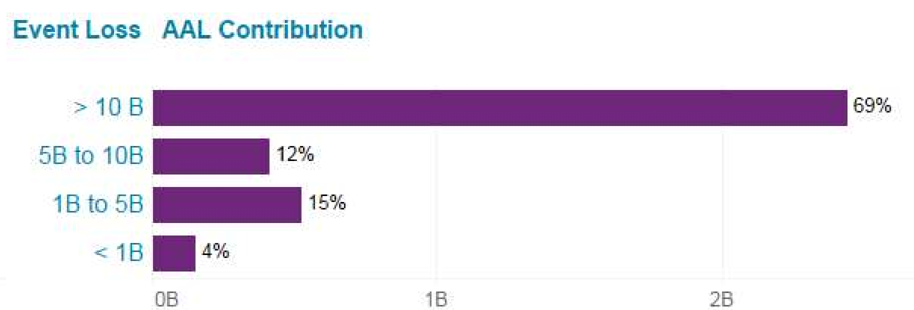
Return Period	Model A	Return Period	Model B
500-yr	1,865M	500-yr	11,181M
100-yr	1,269M	100-yr	3,151M
10-yr	419M	10-yr	255M

- AAL is **less than 2%** different between the two models
- 100-year return period is **148% higher** in Model B than in Model A

AAL Contribution By Event Loss



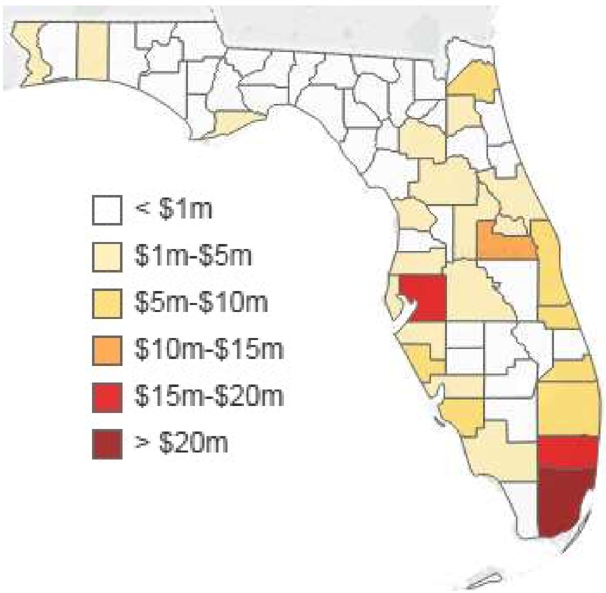
Model A



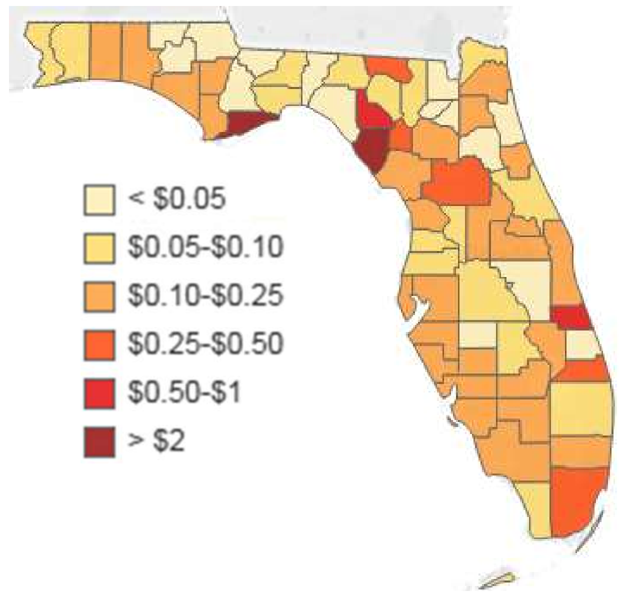
Model B

Geographical Distribution

AAL By County



Loss Cost By County

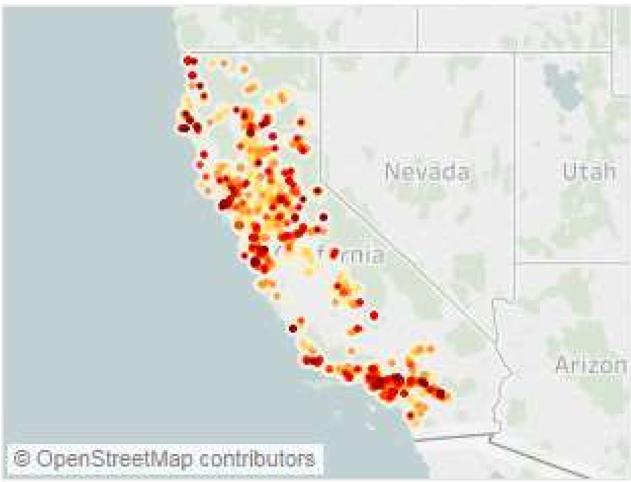


- AAL By County
  - Geographic distribution of loss
- AAL by Location
  - Elevation
  - Flood Zone
  - Proximity to Water

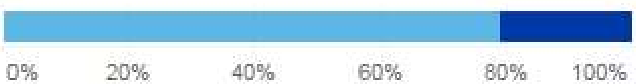
- Loss Cost By County
  - Does distribution make sense?
  - Flash flooding vs. Riverine
- Excess AAL
  - Where are the most severe events occurring?
  - Historical events? Claims Data?

Event Footprints

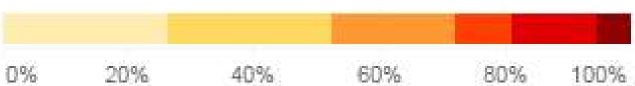
Total Loss:	$223,449,138
% of Locations Impacted:	4.1%
Avg. Loss Per Location:	$21,855



% of Total Loss By Flood Zone



% of Total Loss By Damage Ratio Bin



- What do the events look like at different return periods or event loss magnitudes?
  - All locations placed at ground elevation with slab foundation to capture all of the event
  - Frequency vs. Severity of individual losses
  - % of locations in portfolio impacted and geographic spread of event
  - Distribution of loss by Flood Zone

What else should we be thinking about?

Additional Model Considerations

Geocoding Approach

- Street segment vs. Parcel Based vs. Rooftop Geocoding

Treatment of Flood Prevention Structures

- Source and vintage of levees implemented
- How are levee failures considered?
- How are dams as a flood reduction measure considered in event generation / footprint development?

http://cmisheetpiling.com/

GFDL

Availability of Additional Flood Capabilities

Return Period Floodplain Scenarios

- Return periods available
- Flood depths associated with different return periods

Historical Event Scenarios

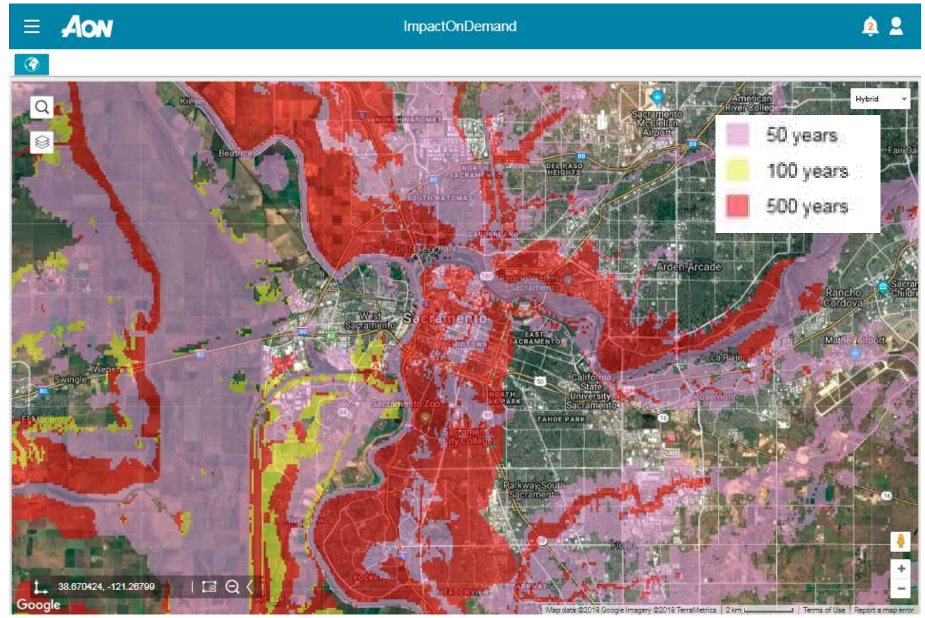
- How many and what events are available?
- Geographic spread

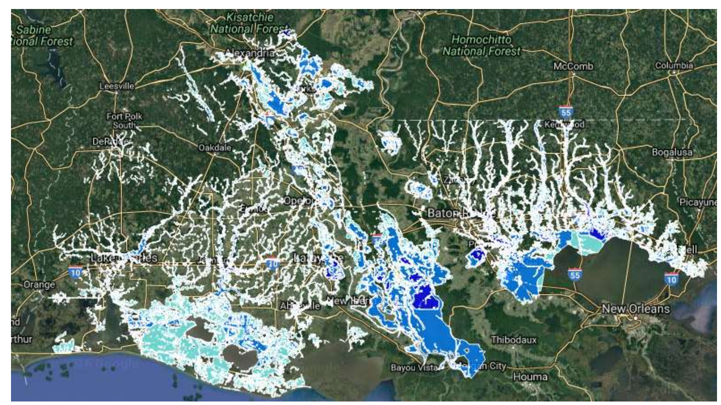
Real-Time Event Modeling

- Availability of aggregation footprints during / quickly after event
- Resolution of footprints

Underwriting Tools

- Flood Zone
- Ground Elevation / BFE
- Distance to Flood Plain
- AAL Grids
- Flood Score





Louisiana Flood Shape (August 2016) shown in IoD

Non-Modeled Risk

“Any potential source of non-life insurance loss that may arise as a result of catastrophe events, but which is not explicitly covered by a company’s use of existing catastrophe models” *Association of British Insurers*

Regions / Perils with No Available Model

Current catastrophe models do not cover all perils and regions globally

- Models tend to focus on peril regions that drive industry loss first
- Need to identify where there may be gaps in available models that correspond with material exposure or potential for loss

Secondary Perils and Effects Not Covered

Primary event characteristics may be represented in a model, but losses from secondary perils may be missed

- Flood Examples: levee failure, hurricane induced precipitation, waterborne debris, tsunami, fire following flood
- Non-Peril Specific Examples: looting, demand surge, LAE, nuclear crisis

Classes and LOBs not covered by models

Not all classes and LOBs at risk in an event are considered for every peril region

- Some examples of LOBs that may not be universally available are:
  - Energy/power risks (offshore platforms, wind farms)
  - Marine risks (inland, goods in transit, yachts)
  - Infrastructure (motorways, bridges)
  - Workers’ comp

Coverages not considered by models

Models typically consider physical damage and BI only

- Some examples of coverages that are likely not explicitly considered are:
  - Residential risks: freezer contents or additional living expenses
  - Commercial / Industrial risks: pollution, debris removal, machinery breakdown, contingent business interruption

Source: “Non-Modelled Risks: A guide to more complete catastrophe risk assessment for (re)insurers” Association of British Insurers

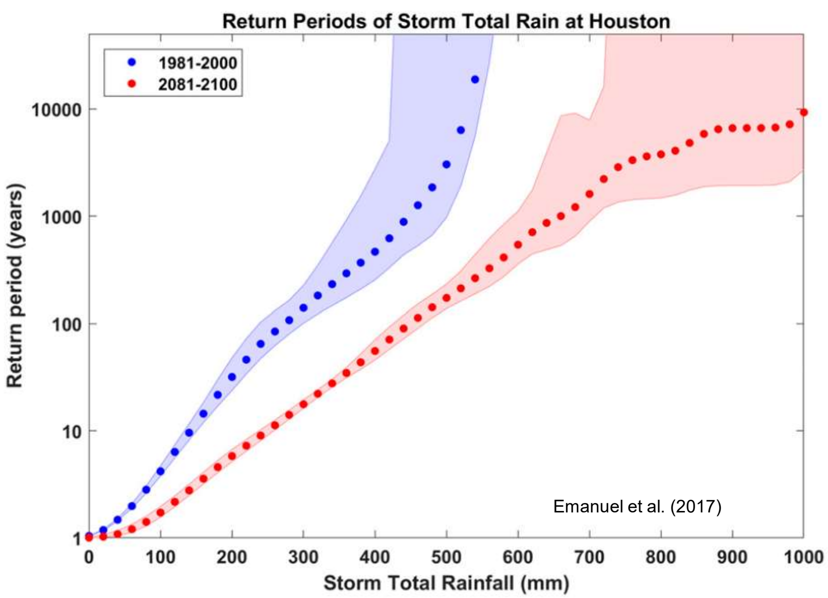
Non-Modeled Risk: An Example from Hurricane Michael

- Damage to your own structure is highly dependent on the performance of your neighbors for both wind and storm surge

Climate Change

Precipitation

- Rainfall rates expected to increase in the future with a warmer atmosphere, which is able to hold more moisture



"Rainfall in excess of 500 mm, which is around a once in 2,000-y event in the late 20th century, becomes a once in a 100-y event by the end of this century." – Kerry Emanuel (2017)

Forward Speed

- Recent academic research indicates that hurricanes may be moving slower, resulting in a longer duration of strong winds and precipitation at a particular location and increased probability of storm surge overlapping with a high tide


nature
International journal of science

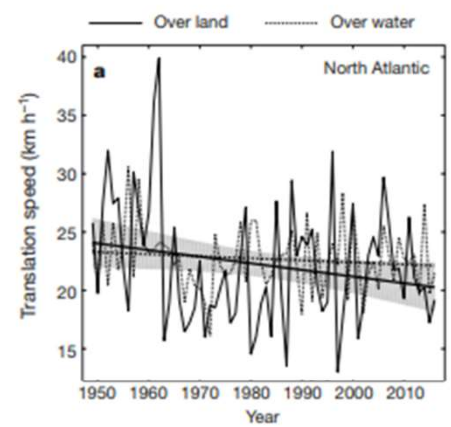
Letter | Published: 06 June 2018

A global slowdown of tropical-cyclone translation speed

James P. Kossin

Nature **558**, 104–107 (2018) | Download Citation

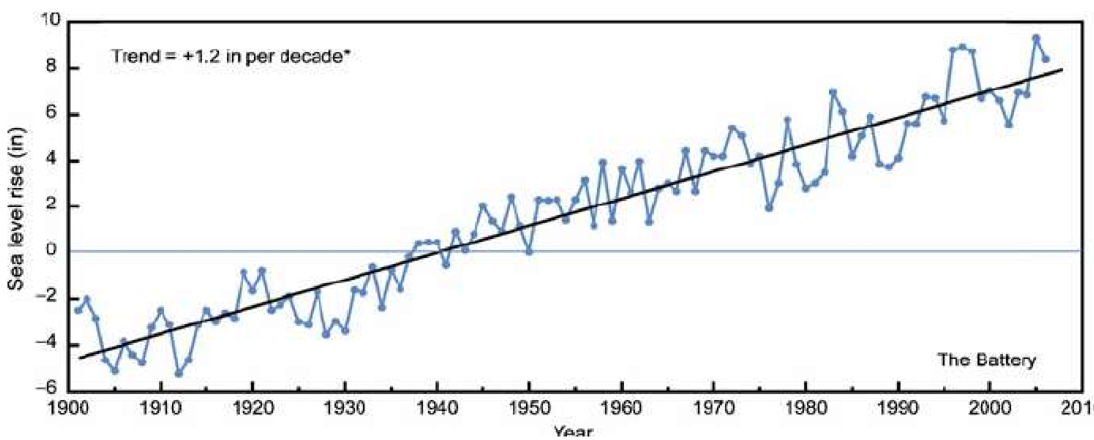
Time series of annual-mean tropical-cyclone translation speed and their linear trends over land and water



Climate Change

Sea Level Rise

- Rising sea levels dramatically increase the potential for damaging floods from storm surge
  Sea level rise along the coastal Northeast expected to exceed the global average rise
- Sea level rise of two feet, without any changes in storms, would more than triple the frequency of dangerous coastal flooding throughout most of the Northeast *(Horton et al 2011)*



Observed sea level at the Battery, New York City. *Trend is significant at the 95% level. Source: Horton and Rosenzweig (2010)

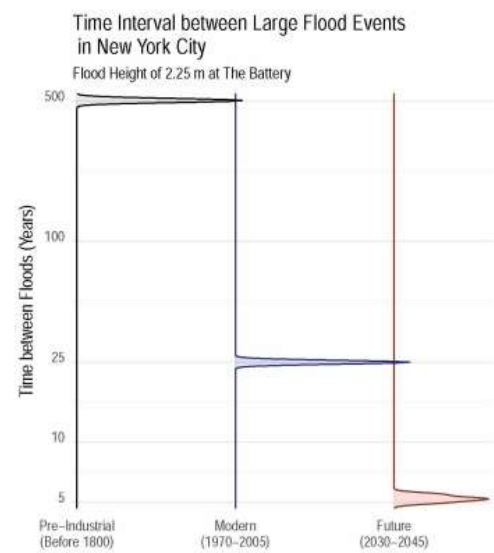


Figure 3. Return periods of the 2.25 m flood height at The Battery for the pre-industrial era (gray), modern era (blue), and future era (red).

Garner et al. (2018)

Closing Thoughts

› Flood is a key growth opportunity (often no. 1 for many reinsurers) and technology and analytics are the key to education, expansion, and profitability!

Flood Models

- More and better flood models entering the market
- Multi-model vendor insights

Spatial Analytics

- Manage aggregations
- Compare risks to FEMA's digital flood maps or floodplains available from other vendors
- Event footprints

Flood Strategy

- A and V zone vs. X zone
  - Improve coverage over NFIP or at a reduced price?
- Personal vs. commercial lines
- Sub-limits
- Set premium (no touch) or strategic underwriting

Implementation

- How to educate policyholders, agents, etc.?
- Reinsurer support
- Platform stability