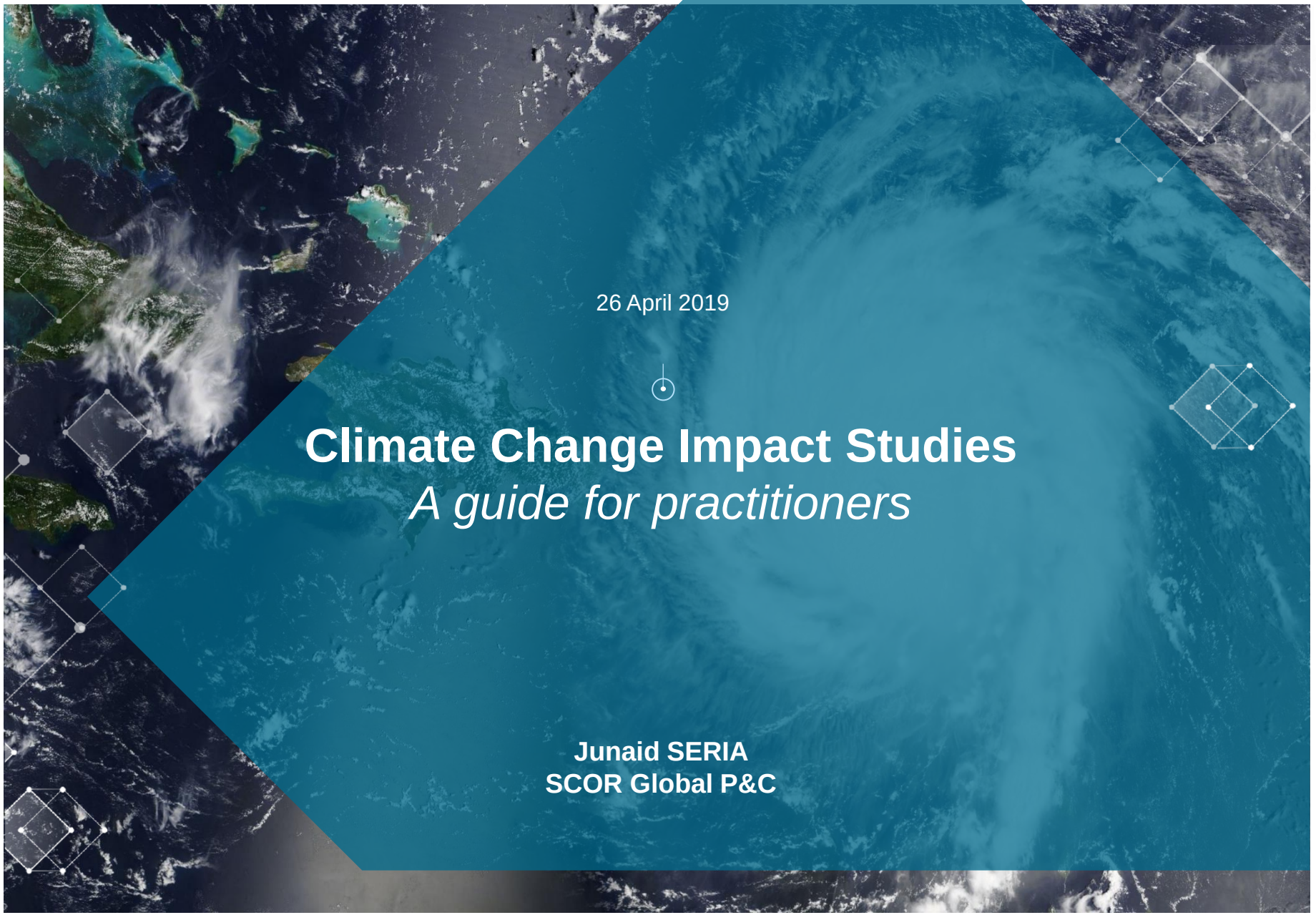


26 April 2019

Climate Change Impact Studies

A guide for practitioners

Junaid SERIA
SCOR Global P&C

SCOR
The Art & Science of Risk

Summary

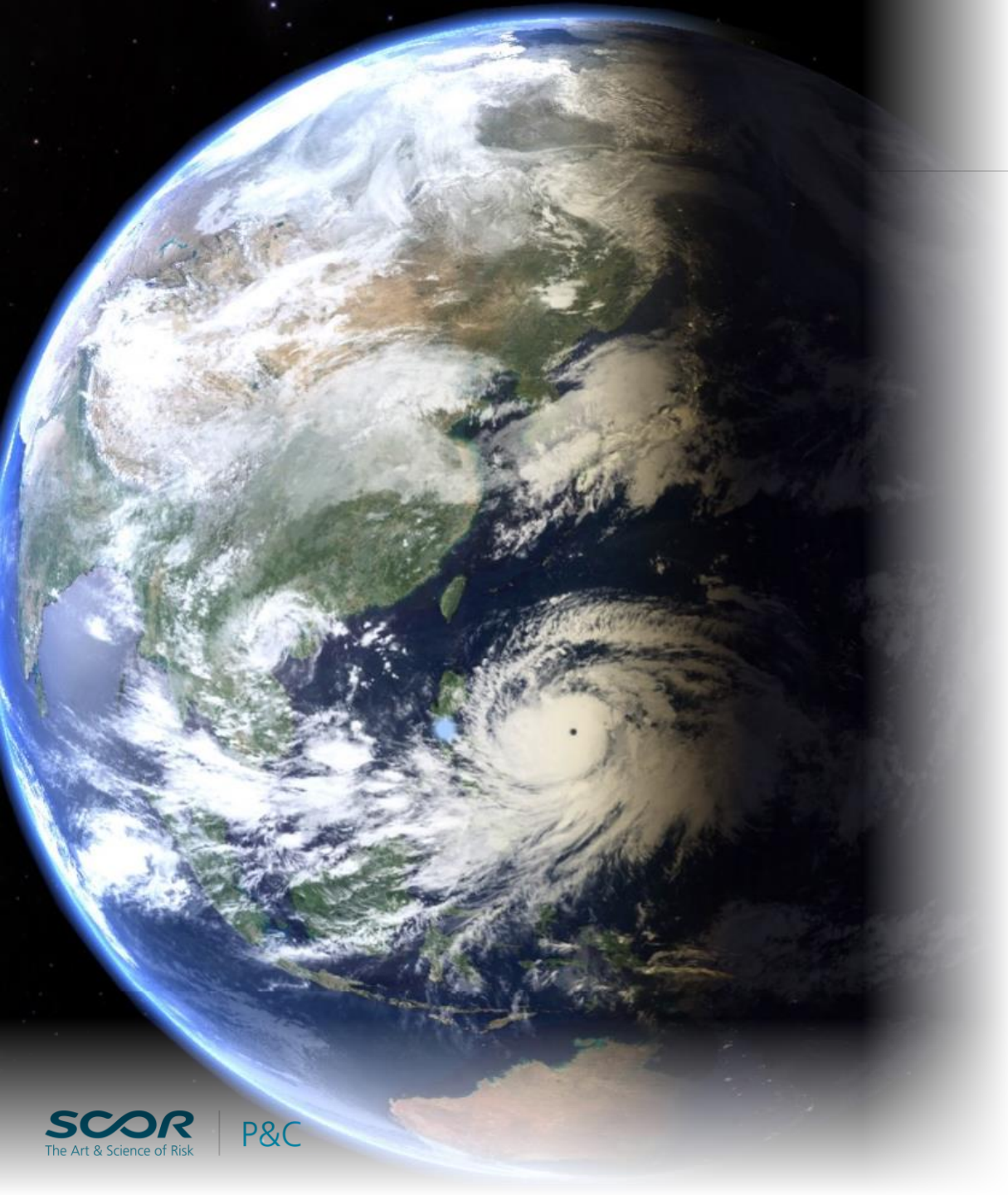
1. We have the tools at our disposal to carry out tests to understand the potential impacts of climate change on key region-perils such as US hurricane risk.

2. “Walk before you run” – e.g., sensitivity tests are useful where a climate signal is not clear enough to implement in risk costing.

3. Climate change sensitivity tests can help inform your ERM framework, potentially in setting your firm’s risk appetite and tolerance level or reinsurance program design. Also an opportunity to be a better corporate citizen through using modelling for advocacy or in public / private partnerships.

AGENDA

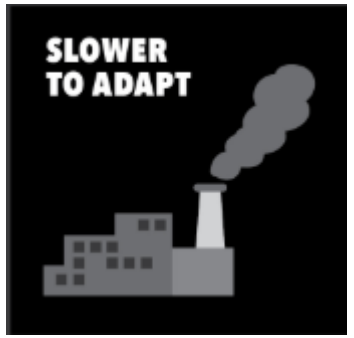
1. Why should we care?
2. What makes this a hard problem?
3. What can we do now?
4. What is SCOR doing?
5. What does the scientific literature say about climate change & NAHU activity?
6. How do we translate potential changes into cat model sensitivity tests?
7. What are the loss impacts and relative sensitivities for inland flood, wind and surge?
8. Q&A



Why should we care?

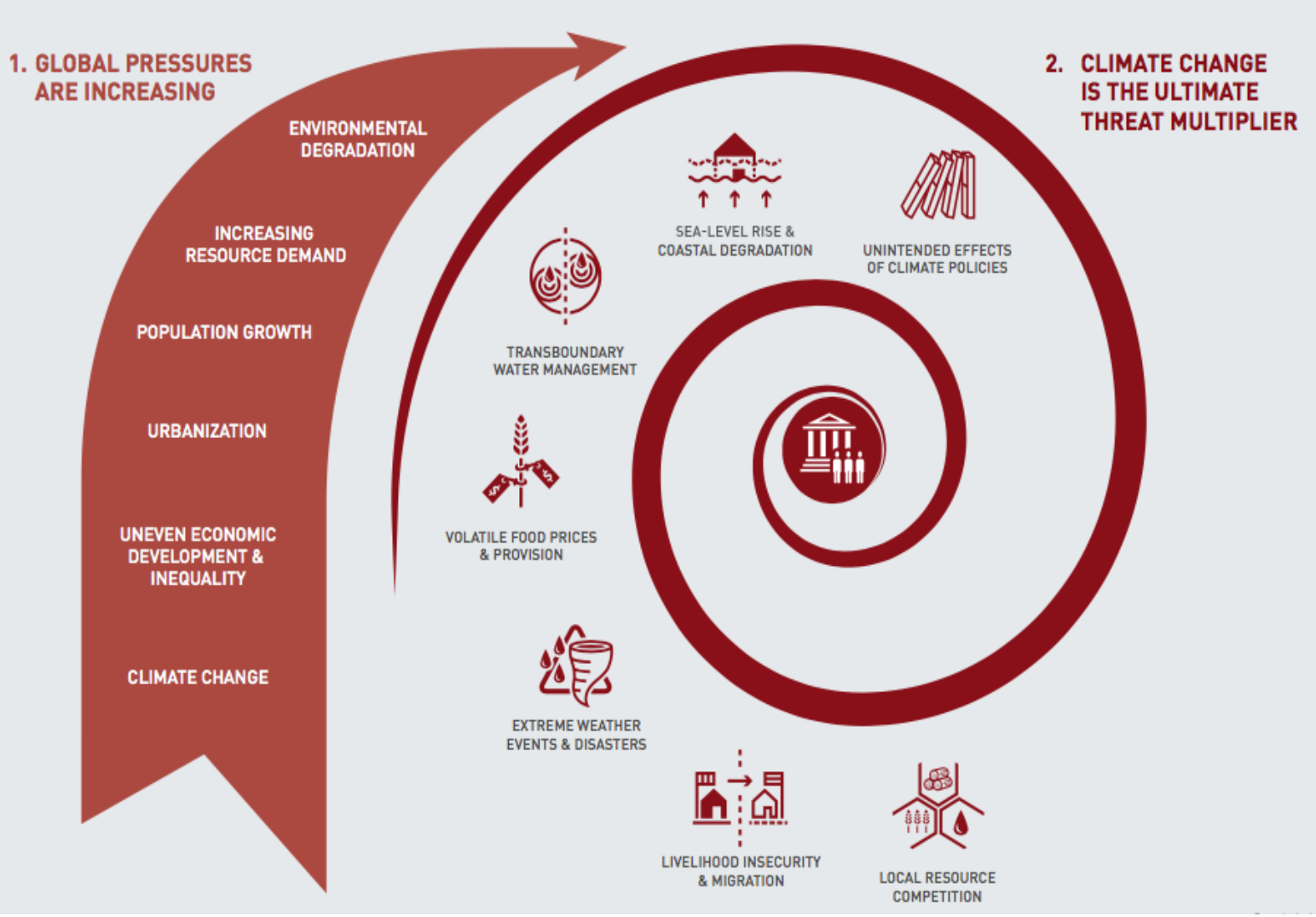
- Resilience of Cities
- Solvency threat
- External scrutiny
- Scientific advancements
- Better tools

1. Resilience of Cities



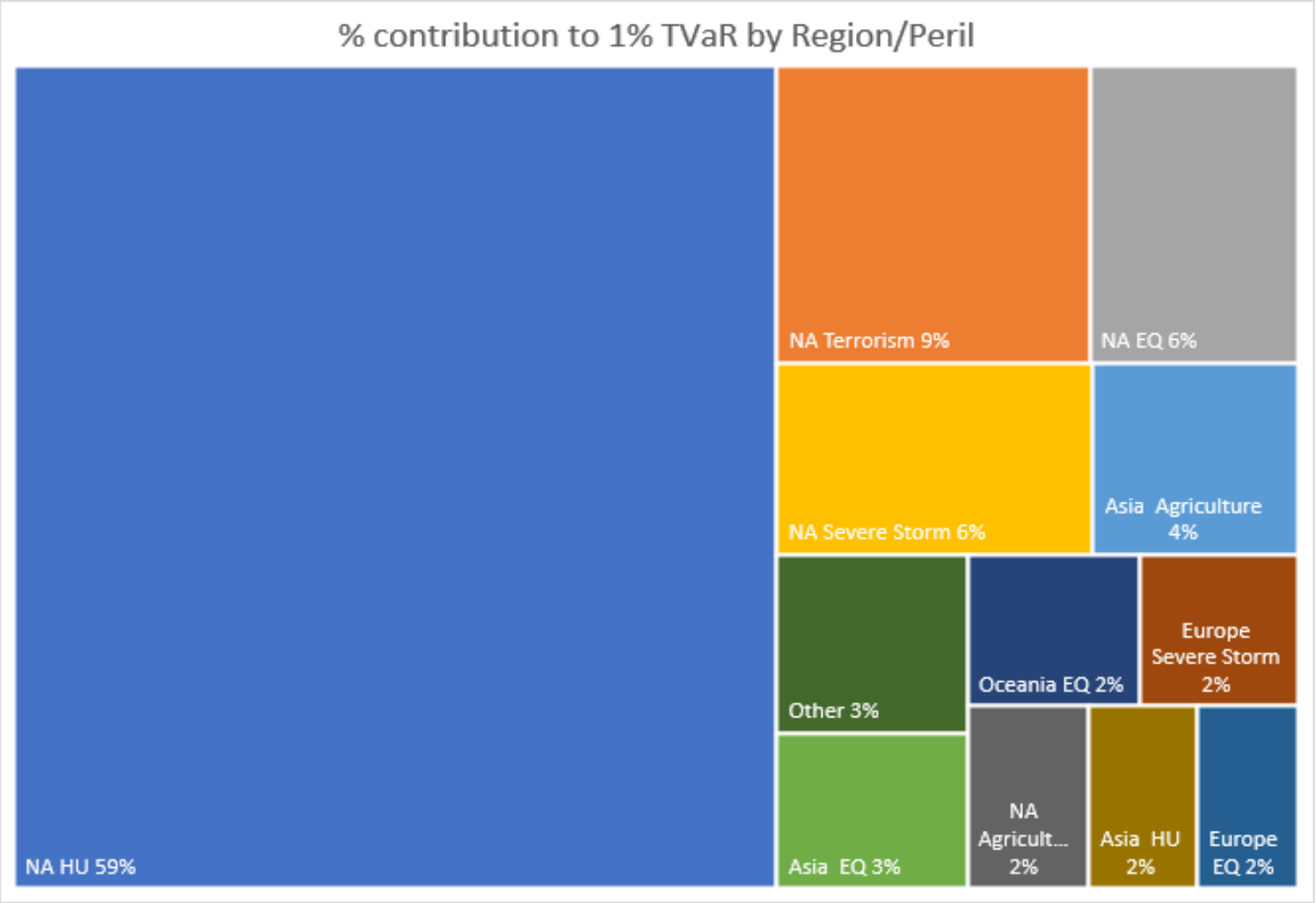
1) Source:Resilient City Infographic: http://lulab.be.washington.edu/omeka/files/original/643ed23f54c7cd7b22c789f264ea0955.jpg

1. Resilience of Cities



1) Source:Resilient City Infographic: http://lulab.be.washington.edu/omeka/files/original/643ed23f54c7cd7b22c789f264ea0955.jpg

2. Hydro-meterological perils pose a threat to P&C Re/Insurer Solvency



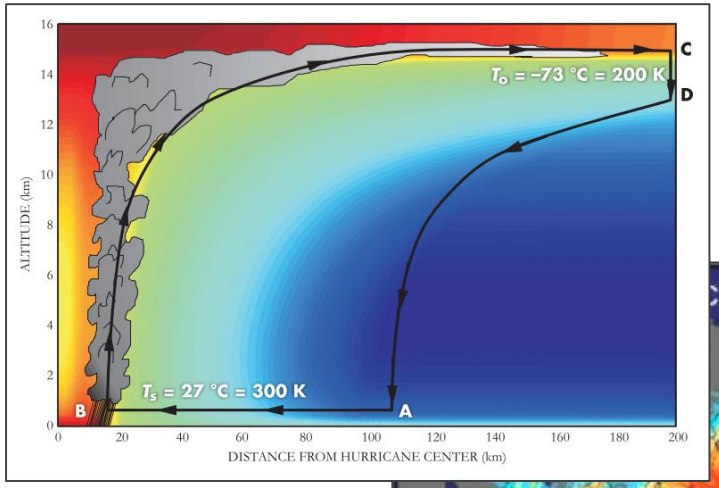
1) AIR, *2017 Global Modelled Cat Losses*

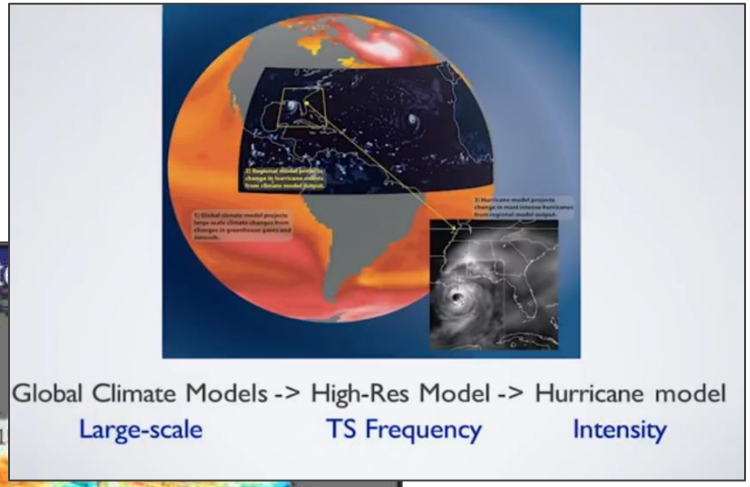
3. External Scrutiny

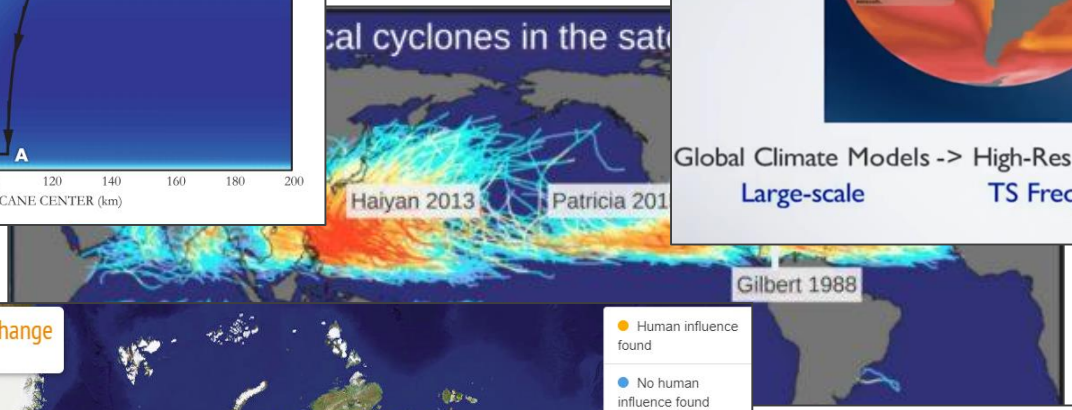
The Board, Regulators, Rating Agencies, Investors and Clients

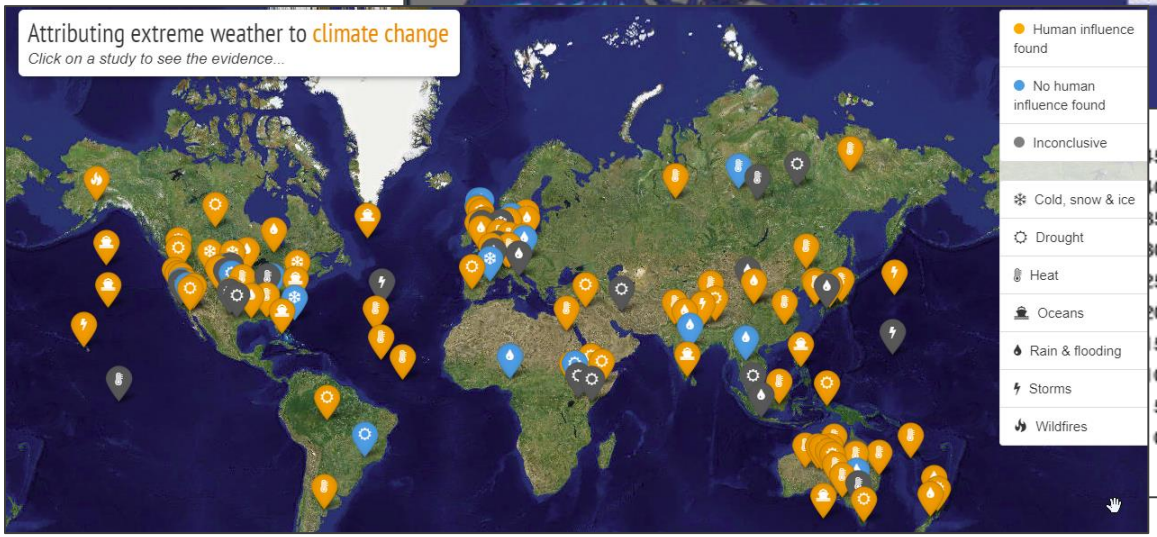
1. Which areas of your business could be affected by climate change?
2. How is climate change expected to influence [region] [peril] property cat losses?
3. What sources of information is used to assess climate change risk?
4. What tools are used to assess climate change risks?
5. To what extent is climate change represented in your vendor cat models?
6. What are you currently doing to better understand the potential impacts of climate change?
7. What controls exist to mitigate these risks?
8. How (and to what extent) do you assess the carbon footprint of assets in your portfolio?

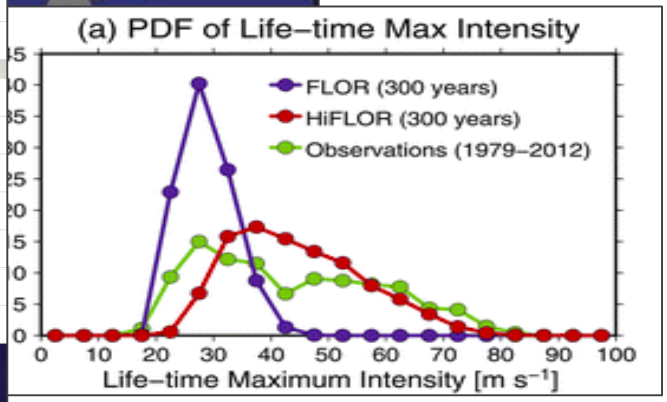
4. Better data, models, understanding…











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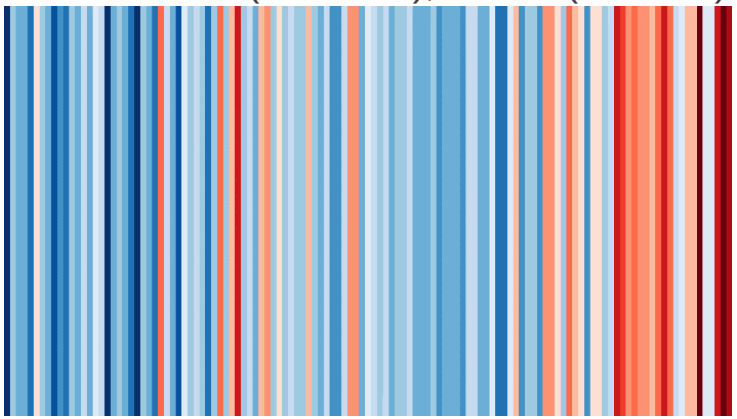
What makes this problem hard?

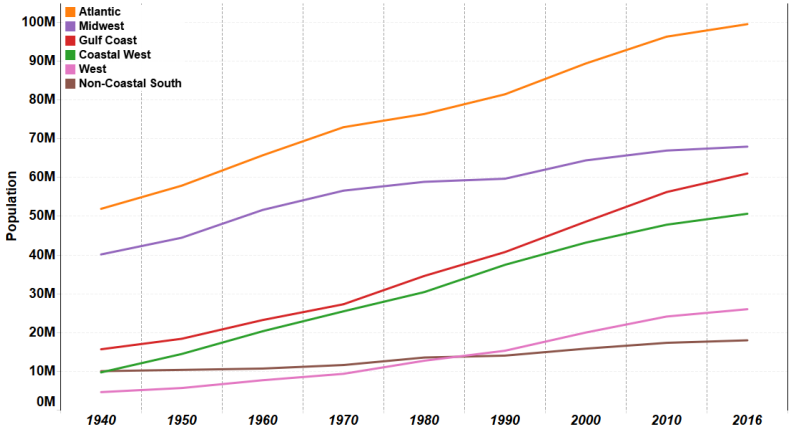
Many moving parts – Loss changes driven by exposure, random / natural variability and climate change

Annual temps for contiguous USA: 1895-2017. 50.2°F (dark blue), 55.0°F (dark red)



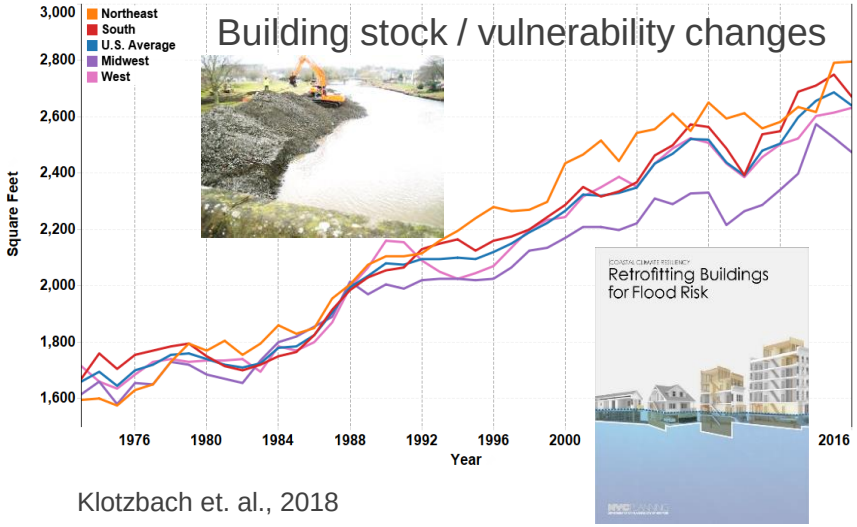
Source: Ed Hawkins

US Population (=>asset) growth



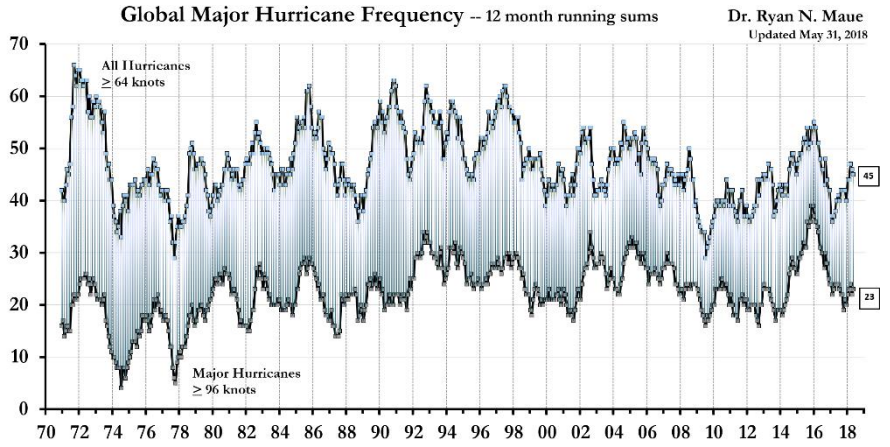
Klotzback et. al., 2018

Building stock / vulnerability changes



Klotzbach et. al., 2018

Significant inter-annual, decadal variability



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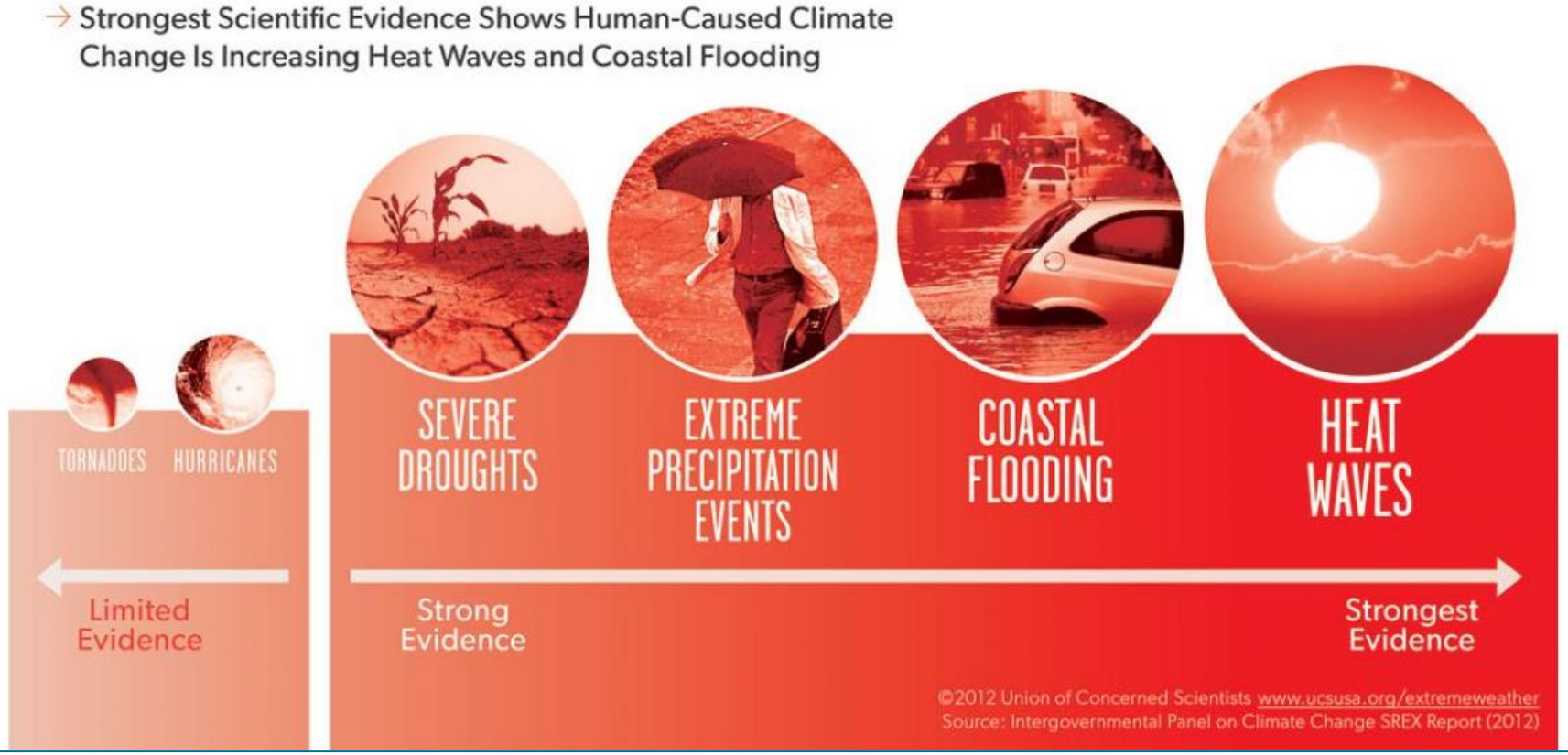
Climate Change and Extreme Events



- link between greenhouse gas emissions and global warming is clear. Link between global warming and extreme events is varied, depending on peril and region.
- However, in general climate change impacts on extreme weather events will imply greater risk for people, assets, economies and ecosystems

2. Trends in TC counts / losses may take many decades to emerge

- **Bender et. al., 2010** estimates it would take **60 years** for a projected increase in frequency of category 4 and 5 Atlantic hurricanes to emerge as a signal in a time series of category 4 and 5 hurricanes
- And even longer in the loss record according to **Crompton et al., 2011** and **Emanuel, 2011**

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Finding the Fingerprints of Climate Change in Storm Damage -- a Very Long Detective Story

By EVAN LEHMANN of ClimateWire

Published: January 4, 2011

PRINT

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- Generous Tariff Lures British Farmers Into Raising Solar Power Arrays

Hurricanes could become more prevalent with climate change, but the economic pain they deliver might not be recognized as man-made for 260 years.

That means smashed homes and ruined roads may not be attributable to greenhouse gases for centuries, according to new research that suggests climate policies like adaptation should be designed without financial evidence of climate-enhanced windstorms.

The researchers also warn environmentalists and policymakers against making claims that damage from Hurricane Katrina and other storms are rising from carbon dioxide emissions. Insurance companies that promote climate change as a reason for rising prices could also lose credibility.

Two distinct groups

Wait and See	Act despite Uncertainty
Minor impact over 1 year time horizon	Increased potential for outsized losses in single year
Natural variability and exposure changes explain most volatility currently	Could be gradual changes over time (which may not be detectible for many decades)
Weak/no detectable signal in Nat Cat losses	Corporate citizens (e.g., reduce protection gap, cost climate change)
Difficult to implement pricing increases in a soft market	Inaction is reputationally damaging, and could miss upside opportunities (climate change product?).
Let's wait for the model vendors	ERM – climate change, like cyber is a systemic risk that we need to understand

What can we do now?

Consider push / pull factors affecting your firm

- Push factors:
  - External scrutiny which compels us to educate ourselves and form a view
  - Large range of stakeholders questioning our staff compels us to ensure we have an internally consistent view
- Pull factors:
  - opportunity for better risk costing,
  - better decision-making,
  - new products,
  - thought leadership?

What is SCOR doing?

- Divesting from coal
- Developing underwriting scorecards to incentivize efforts to reduce client carbon footprints
- Designing alternative event catalogues conditioned on future climate states
  - California wildfire as a case study
- Conducting scenario testing to inform risk tolerance setting
- View of risk: where covered, incorporating explicit loading for wet hurricanes
- Model evaluation: ensure calibration of surge heights reflect intensity changes and sea level rises
- Update loss calibration based on recent events
- **NOT** attempting to add explicit “climate change” loading to treaty pricing

What is SCOR doing?

Illustrative

	P&C	Life	Investments
Business potentially impacted	➢ Property Change in frequency and/or severity of floods, storm surge, landslides, drought, wildfires, social unrest (+&-) Business Interruption and Contingent Business Interruption. (-) ➢ Casualty Environmental Impairment Liability (EIL), E&O and D&O resulting from climate litigations. (-) ➢ Agricultural (+&-) ➢ Credit and Surety, Marine and Aviation resulting from the transition to a low carbon economy (-)	➢ Mortality Change in mortality resulting from heatwaves or infectious diseases (-) ➢ Longevity (+) ➢ Critical Illness/ Medical expenses Rise of the risk of cardiovascular and respiratory diseases (-)	➢ Potential stranded assets in the following industry sectors (-) : Oil & Gas (exploration, production, drilling, services, transportation) Coal Auto Manufacturers Auto Parts & Equipment Airlines Transportations ➢ Initiatives to support transition to a low carbon economy (+) Investments in renewable energy companies Infrastructure financing Real Estate investments in energy efficient buildings Green bonds
Insurability	➢ Pooling mechanisms (-) Public / private ventures (+) ➢ Rising inequalities (-) or closing the protection gap (+)		
Affordability	➢ Premiums (insurance, reinsurance and retrocession) may rise as to be uneconomic or unaffordable for the customer (-)		
Risk of accumulation	➢ As a result of increased severity and/or frequency of events in exposed areas (-)		➢ Transition to low carbon economy will have a cumulative impact on all investments linked directly or indirectly to fossil energy. (-)

How to do a US hurricane risk climate change impact assessment? A possible framework

1. Perform literature review to identify which hazard variable(s) to adjust and to what extent.

2. Design and implement cat model tests:

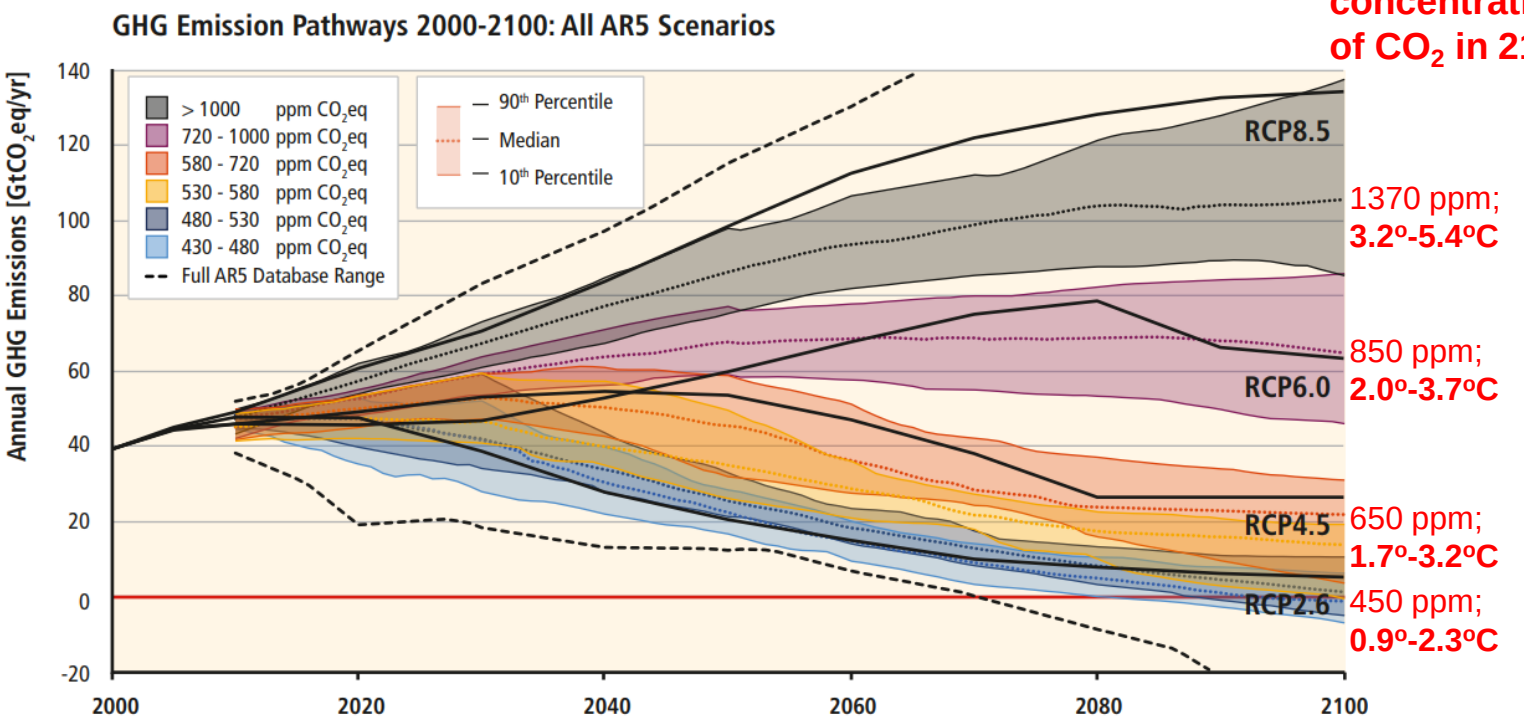
   Translate changing hazard variables into “what-if” scenarios that can be implemented in your cat model. These could be implemented as a change across all / part of stochastic event set or as a set of imagined events to use as a scenario test (e.g., wetter hurricanes, higher surge)

3. Incorporate in your Enterprise Risk Management framework, for example by considering:

   - Impact on your firm’s 3-5 year strategy
   - How this study could help inform your firm’s risk appetite / tolerance statement, reinsurance purchase or help raise awareness of the issue among Board members

IPCC Representative Concentration Pathways (RCP)

- RCP scenarios capture future levels of human interference with the climate system
  - Provide consistent link between perils for underlying sensitivities



Atmospheric concentrations of CO_2 in 2100

1370 ppm; **3.2°-5.4°C**

850 ppm; **2.0°-3.7°C**

650 ppm; **1.7°-3.2°C**

450 ppm; **0.9°-2.3°C**

1) Figure adapted from IPCC WGIII AR5 Report (https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_full.pdf)

North Atlantic Basin Literature Review Summary

Possible future hurricane enhancements	Estimated Impact for NA basin by late 21st century relative to current climate
Surge severity due to projected sea level rises and increases in hurricane intensity	Combined loss impact of 11%-20% increase in AAL (based in RCP8.5) – in this case projection by 2030. +0.4 m increase (RCP4.5) and 0.6 m increase (RCP 8.5) by 2100
Rainfall rates	+18% increase within 100km of TC center (RCP4.5)
Hurricane intensity	+4.5% increase in lifetime maximum wind speed of hurricane strength tropical cyclones (RCP4.5)
Frequency of Cat 4 & Cat 5 hurricanes	+42% Cat 4-5 hurricanes (not statistically significant; RCP4.5)
Frequency of TCs	-9.4% decrease for TC (not statistically significant; RCP4.5)
Storm size	+11% increase in median storm size (RCP4.5)
Rapid Intensification	60 knot / 24 hrs: change in RP from 1:100 to 1:20-1:30 (using current TC frequency assumptions to isolate RI changes; RCP8.5)
TC Genesis, LMI latitude and landfall changes * *Observed changes* ** *GCM projection*	Eastward migration of TC genesis (increase frequency in tropical East NA, reduced frequency in tropical West NA)** North and eastward migration of extra tropical transition (increased frequency in mid-latitude NA) **

Cat Model Implementation: a Challenging Problem…

- How to translate hazard changes into catastrophe model sensitivity tests?
- Some things to consider when designing the sensitivity tests:
  - Which business decisions (if any) are you looking to influence?
  - Whether (and how) to represent exposure changes?
  - Whether to consider interaction between hazard variables? (or isolate impacts)
  - Which IPCC scenario(s) to select?
  - What timescale (2020, 2050, 2100…)?
  - What loss metrics to examine?
- How to deal with *closed* vendor models? (i.e., little / no flexibility within the hazard / vulnerability modules)
  - Partnered with KatRisk to help SCOR implement the climate change sensitivity tests
    - Functionality to carry out climate change impact assessment

Potential Cat Model Sensitivity Tests

Future Hurricane Enhancements	Cat Model Sensitivity Tests
Increased surge severity due to sea level rises and increased in max sustained windspeeds*	• Identify surge events in stochastic catalogue, apply loss loading based on RCP scenario and time horizon. • Consider regional impacts and coverage conditions when estimating loading factors.
Increase in hurricane rainfall rates (supported by observed reduction in forward speed)*	• Constrain subset of “wet” hurricanes based on forward speed and duration post landfall, apply event loading for freshwater flooding. • Consider changing mix between “wet” and “dry” hurricanes. • Consider coverage conditions.
Increase in hurricane intensity increases risk of wind damage*	• Assuming stochastic set includes future more intense storms, bin hurricanes by intensity and calculate relative loss loads / intensity bin as a proxy. • Apply event loading factor.
Decrease in frequency of weaker TCs and increase in frequency of stronger (Category 4-5) TCs	Sample fewer (more; 5%, 10%, 20%) weak (strong) storms into simulated years and recompute loss statistics or increase / reduce frequency of stochastic years to preserve event sequence within a stochastic year

** No change in hurricane frequency assumed.*

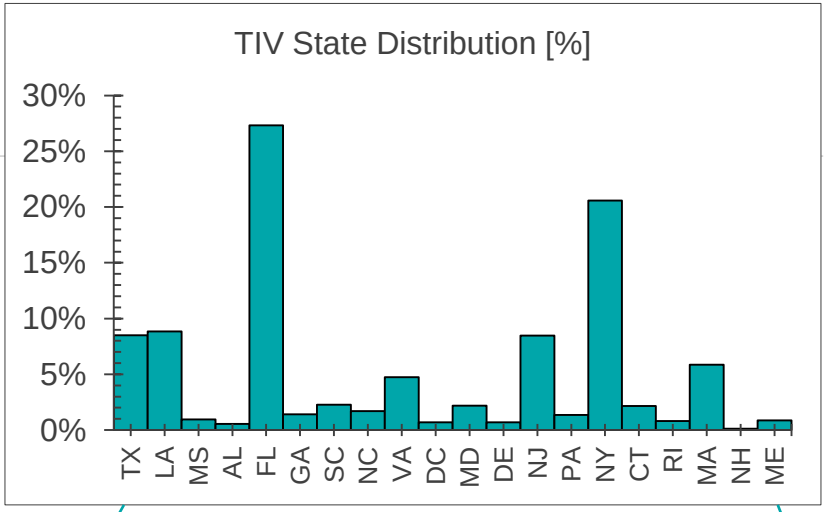
Sensitivity Test setup

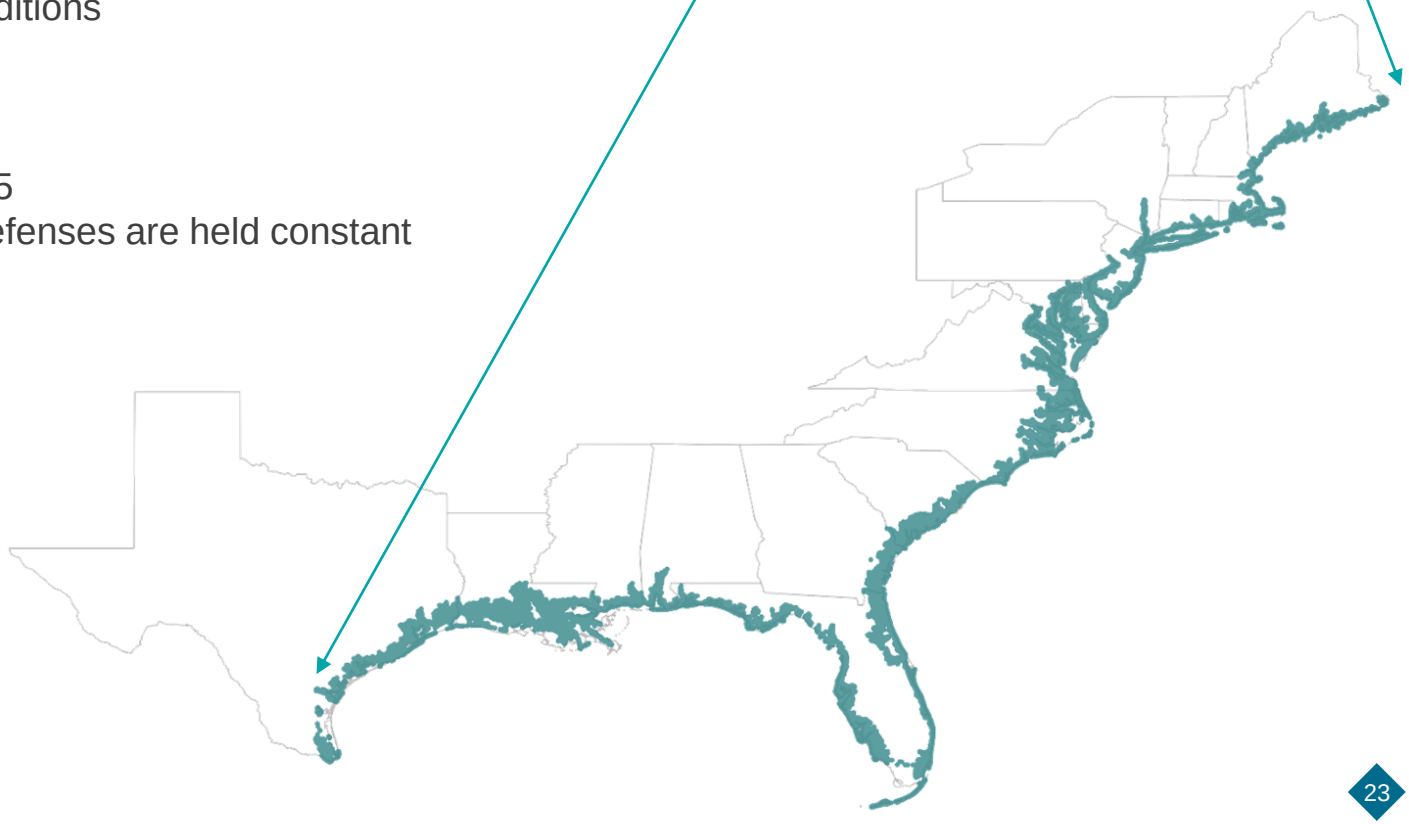
Exposure data:

- Hypothetical coastal portfolio of ~900k locations along the US east and gulf coasts totaling ~$650 Bn
  - 60% building, 30% contents, 10% BI
  - Present day values with current wind and flood insurance conditions

Key assumptions:

- Time horizon: 2100
- RCP scenario: RCP4.5
- Exposure and flood defenses are held constant at present day values



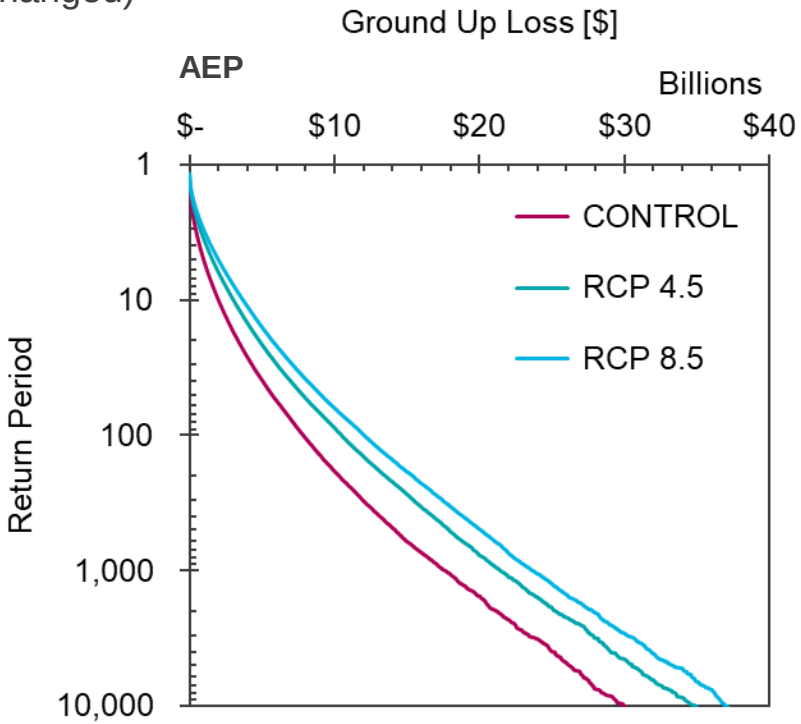


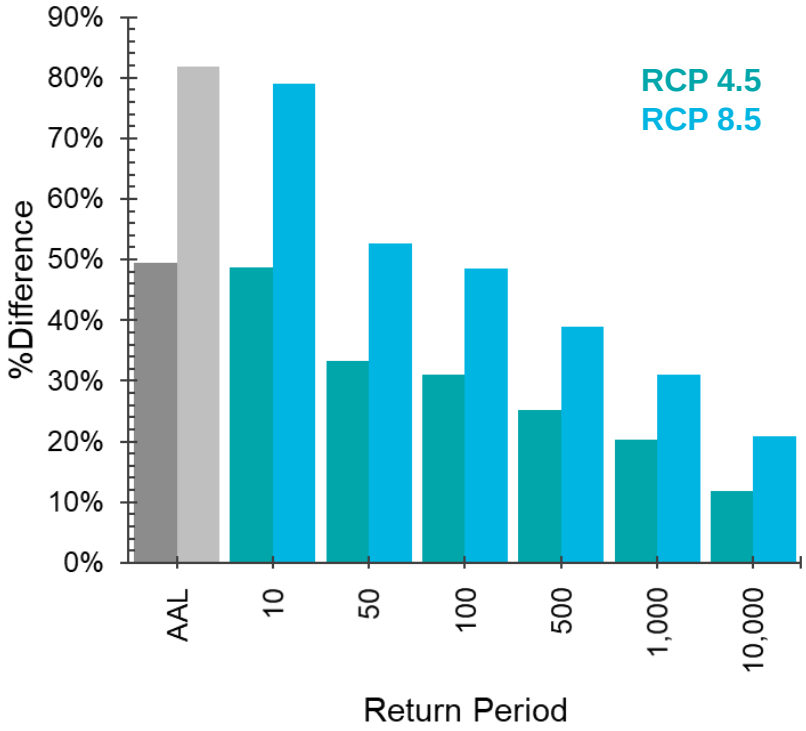
Sensitivity 1: Sea Level Rise (Storm Surge) in 2100 Relative to Present

Goal: examine the loss impact of sea level rise on storm surge losses in isolation

Catastrophe Model Implementation: add projected SLR in RCP4.5 (0.4 m) and RCP8.5 (0.6 m) to flood depths for surge events

Assumptions / Limitations: (i) no regionality in sea level rise, (ii) flood extent kept constant (depths are changed)



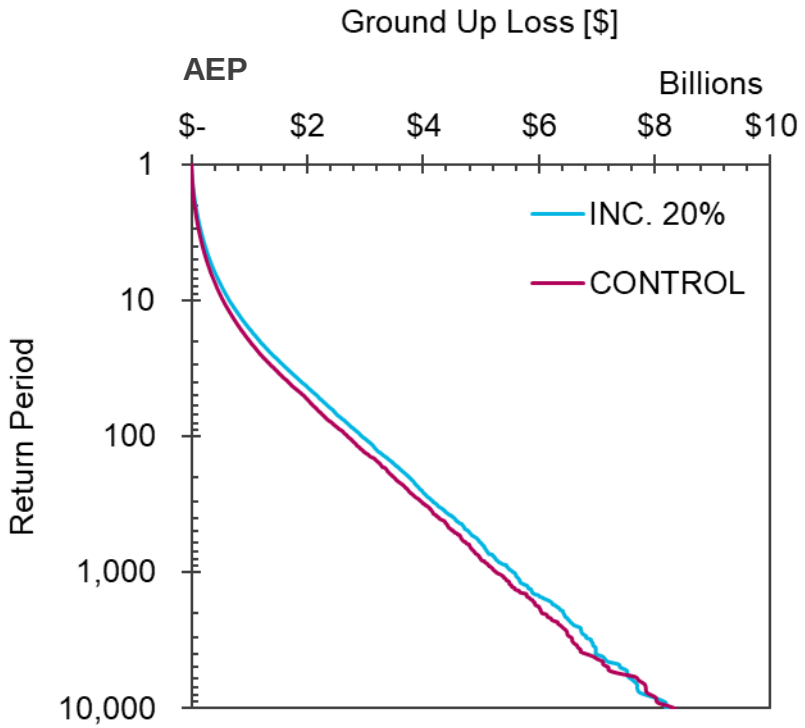


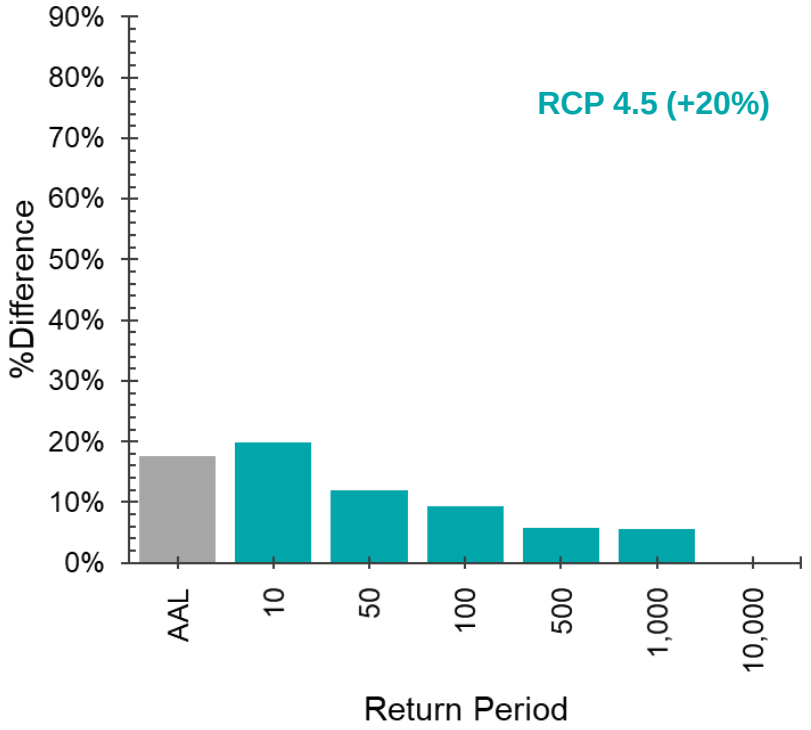
Sensitivity 2: Increased Precipitation (TC Flood) in 2100 Relative to Present

Goal: examine the loss impact of increased precipitation from hurricanes in isolation

Catastrophe Model Implementation: increase the return period of local flood depths by 20% (RCP 4.5)

Assumptions / Limitations: (i) rainfall rate changes translate proportionally to flood depth return period changes, (ii) uniform changes across the US



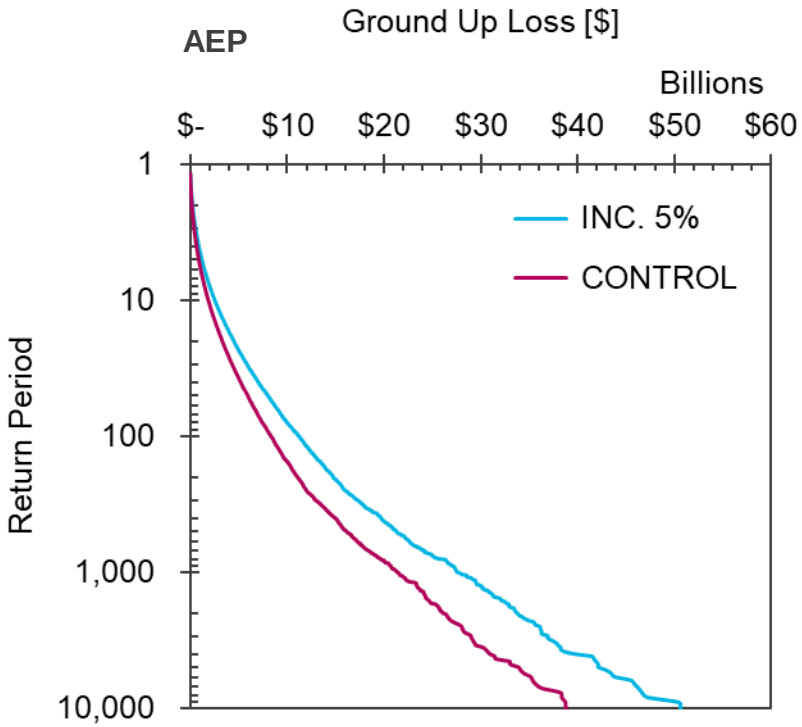


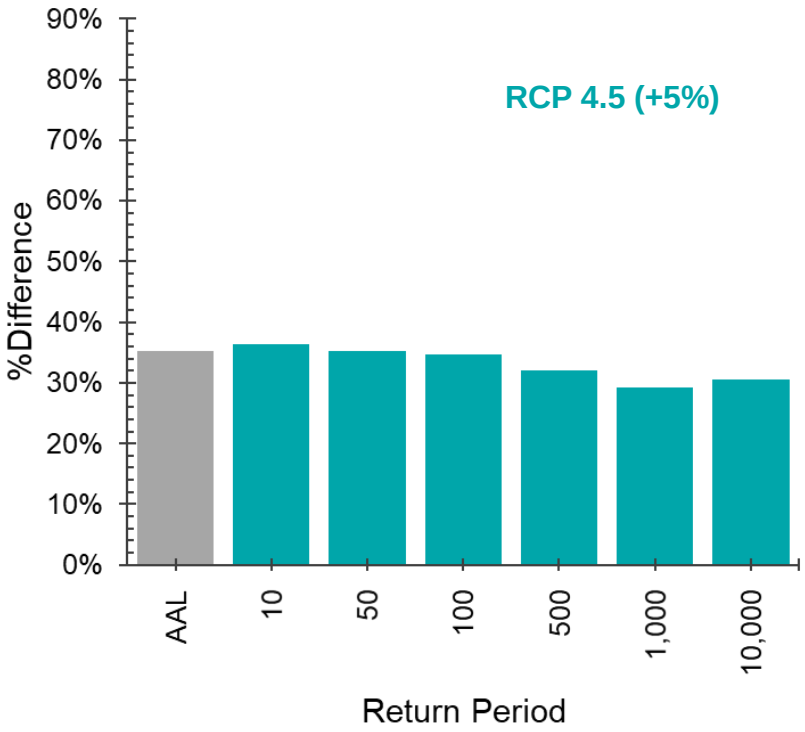
Sensitivity 3: Increased Intensity (Wind) in 2100 Relative to Present

Goal: examine the loss impact of increased windspeed for NA hurricanes in isolation

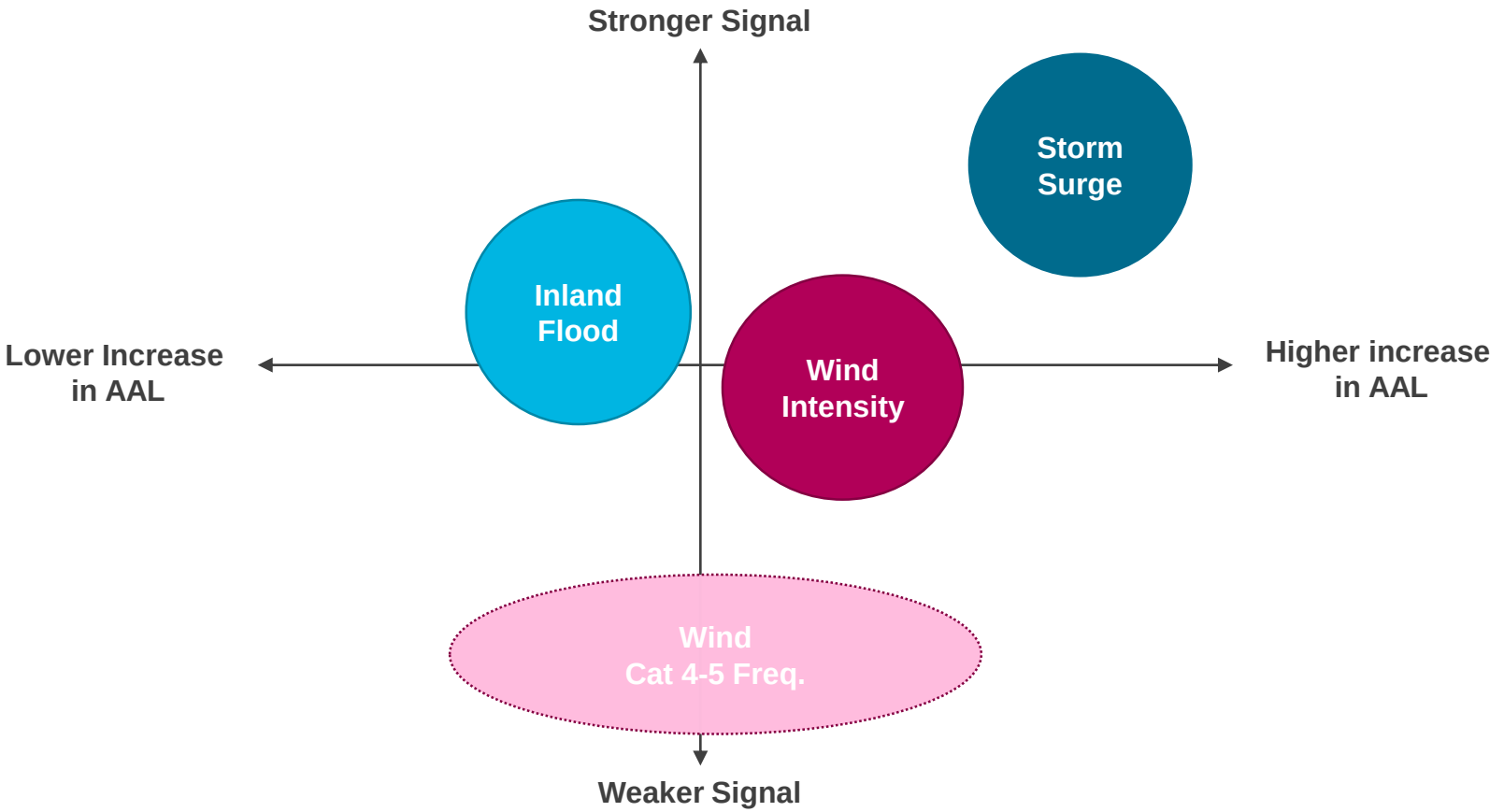
Catastrophe Model Implementation: increase the wind speed vulnerability to give mean damage ratio corresponding to a 5% increase in wind speeds

Assumptions / Limitations: (i) landfall wind speed changes proportional to changes in mean lifetime-maximum intensities, (ii) uniform uplift across US coastline





Relative Sensitivities and Uncertainty



- The case study yields intuitive results given **coastal portfolio**
- Strong urge to generate combined results, but given uncertainty in interaction between perils, we felt this could be misleading

Summary

1. We have the tools at our disposal to carry out tests to understand the potential impacts of climate change on key region-perils such as US hurricane risk.

2. “Walk before you run” – e.g., sensitivity tests are useful where a climate signal is not clear enough to implement in risk costing.

3. Climate change sensitivity tests can help inform your ERM framework, potentially in setting your firm’s risk appetite and tolerance level or reinsurance program design. Also an opportunity to be a better corporate citizen through using modelling for advocacy or in public / private partnerships.