MOODY'S ANALYTICS | SUMMIT 2023

Climate Risk Assessment: Best Practices for Quantification of Physical Damages

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Introductions:

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Moody's Analytics

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Climate Risk Models
Moody's RMS

Agenda

1. The challenge of quantifying physical climate risk
2. Climate and extreme weather risk modeling
3. Climate Change Impacts on UK Flood Risk
4. An example of incorporating flood hazard forecasts in credit mortgage analytics

1 The challenge of quantifying physical climate risk

How is Extreme Weather Impacted by Climate Change?

HIGH

LEVEL OF CONFIDENCE

LOW

COASTAL FLOOD

SEA LEVEL RISE

INLAND FLOOD

PRECIPITATION

WILDFIRE

PRECIPITATION
WIND

TROPICAL CYCLONE (TYPHOON)

SSTs
ENSO
STEERING
OTHER FACTORS

EXTRATROPICAL (WINTER) STORM

JET STREAM
ENSO
OTHER FACTORS

SEVERE CONVECTIVE STORM

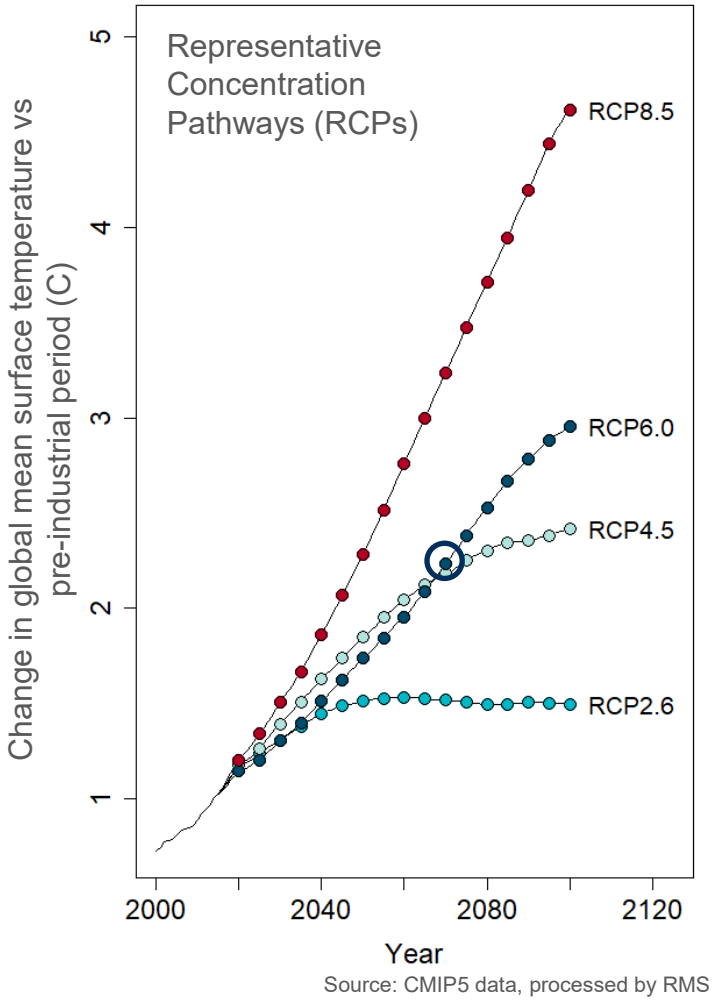
VARIOUS
MICRO AND
MACRO
FACTORS

- Each region & weather peril must be studied individually
- Scientific consensus is easier to determine in some cases
- For some weather perils, there is a very high degree of uncertainty

Interconnectedness of Risk

Climate Change Challenge

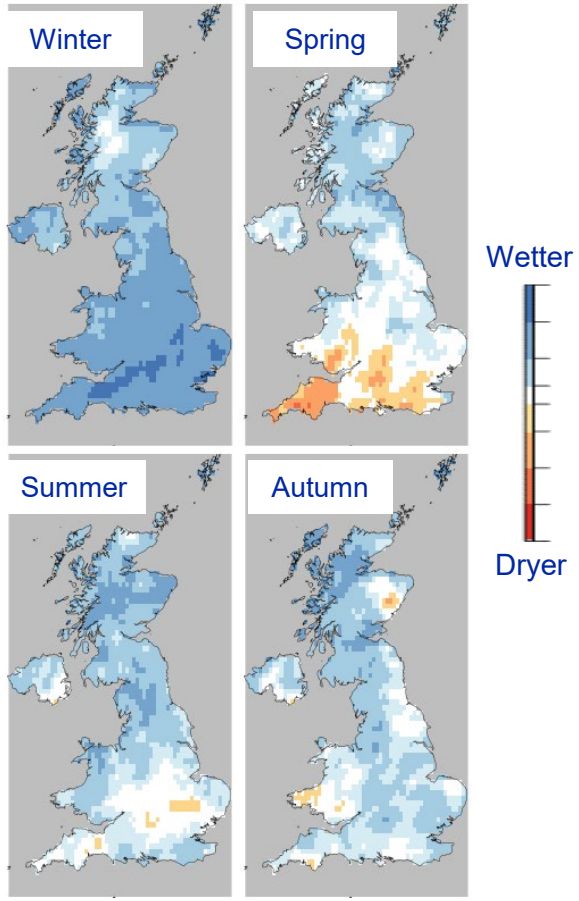
Turning this…



Source: CMIP5 data, processed by RMS

… via this…

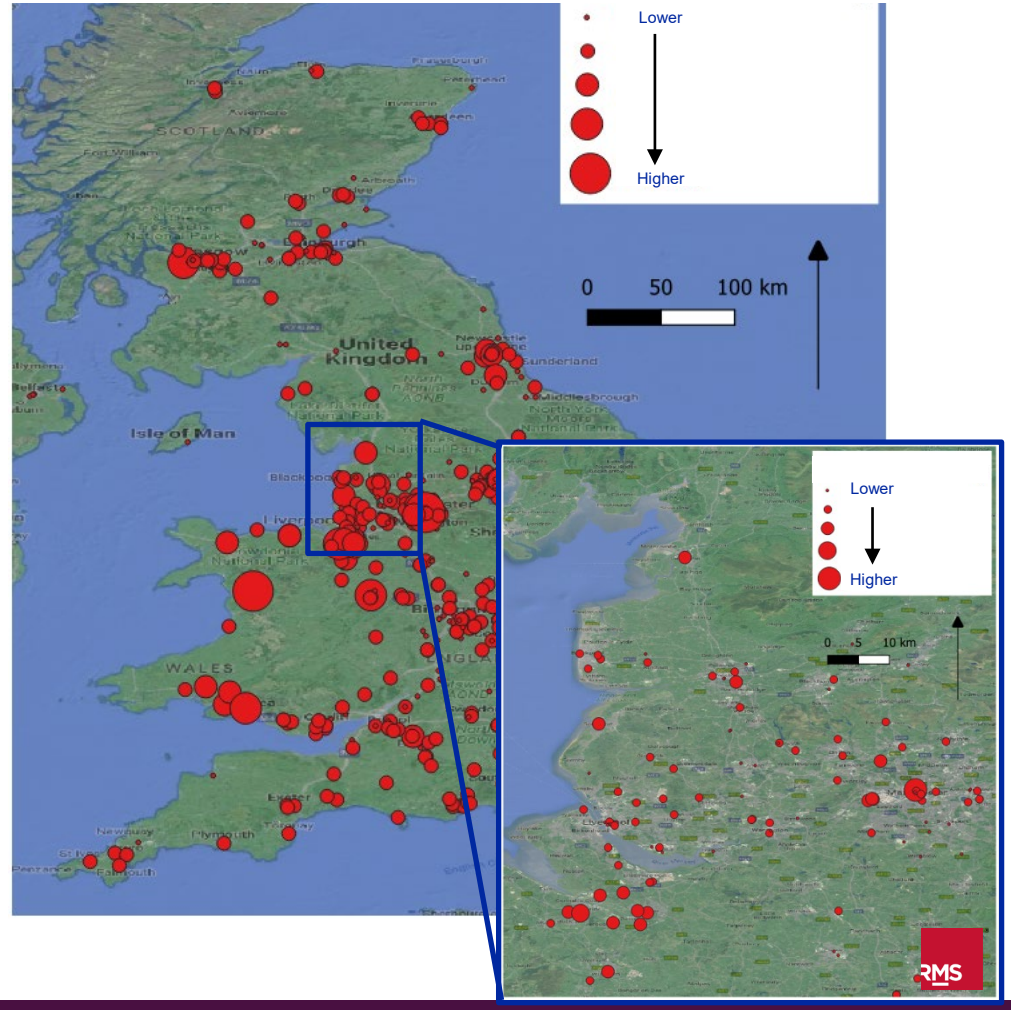
Change in daily extreme precipitation: 2041-2070 vs present



Source: EURO-CORDEX data, processed by RMS

… into this

Change in Average Annual Damage



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Climate and Extreme Weather Risk Modeling

Quantifying the Impact of Climate Change:

How Much Damage and Business Disruption? What will it Cost?

Hazard scores answer the question "how likely is it that a location experiences high winds, flood water, fire etc."

Damage values answer the question "what level of loss or disruption should be expected at a location or for a portfolio?"

Hazard
wind speeds, flood depths, temperature extremes, water deficit, etc

Impact
physical damage, $loss, assets, machinery, equipment etc

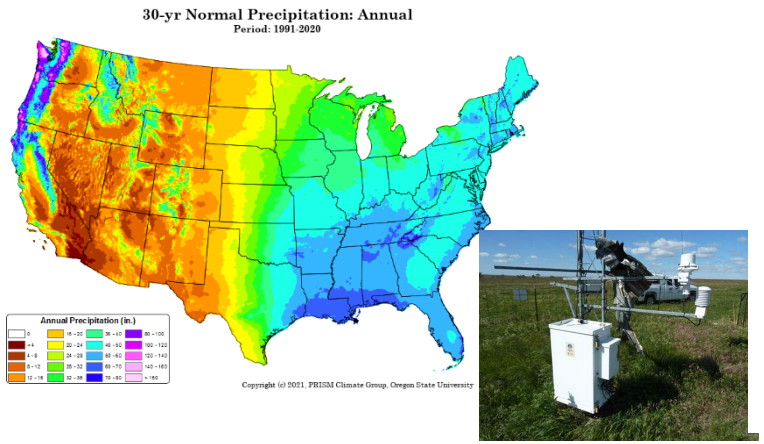
Downtime
number of non-operational days post event, loss of income

Unified Risk Assessment

Climate & Catastrophe Risk Models

Complementary (But Different)

Historical Data



Resolution: location - 100kms

Captures climate & weather

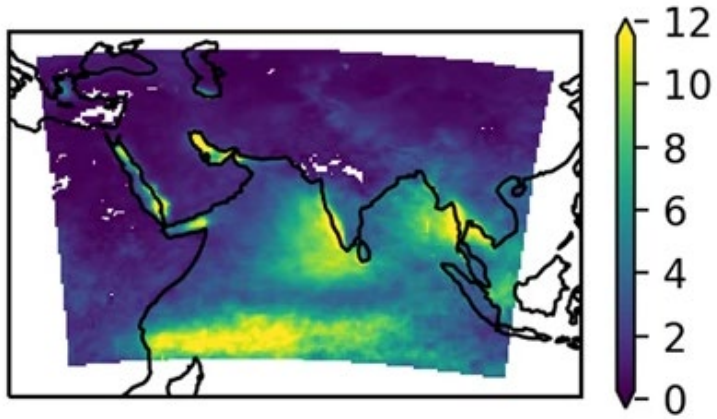
10-100 years of observations

Measurements

Damage (claims) & Hazard

Historical & Current Climate

Climate Models



Resolution: 10km-100kms

Captures climate and/or weather *(sometimes)*

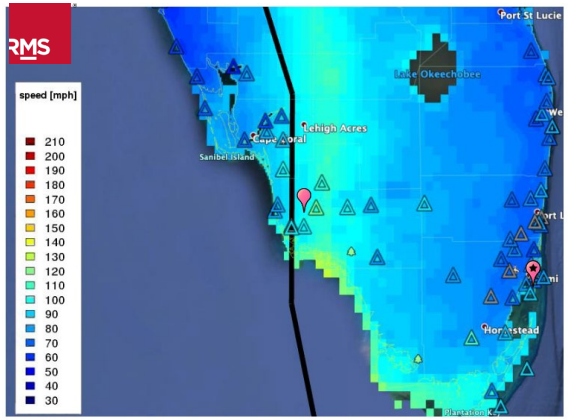
10-100 years of simulations

Dynamical physical modeling

Hazard

Historical, Current & Future Climate

Catastrophe Risk Models



Resolution: <50m-10km

Captures extreme weather

10,000-1,000,000 years of simulations

Dynamical & statistical physical modeling

Damage (financial modeling) & Hazard

Current & Future Climate

Catastrophe Model Framework

What's the hazard?

Bottom up weather simulations capture **the physics** and dynamics of **real-world weather and climate** events

Embedded Climate Science characterize correlated and compounding hazards

Integrate **Climate Model output and Scientific Consensus** for forward-looking risk analysis

What's the damage?

How much $value is in harm's way of likely hazards

Thousands of **impact curves** to understand how assets and businesses react to hazard

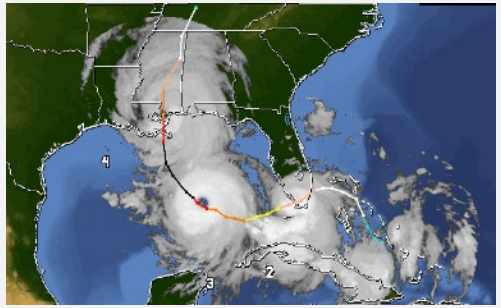
Based on decades of analysis of real-world impacts as measured by insurance claims, losses and damage surveys

Financial Impact?

- Assets
- Business Interruption
- Suppliers
- Credit
- Mortgages
- Insurance

Global Impacts of Chronic & Acute Risk

Tropical Cyclone



- Wind, tornados, wind-blown debris, rainfall ingress into roofs and super-catastrophe inflation effects on loss

Inland Flood

- Riverine and flash flooding from heavy rainfall at high-definition scales 30m globally

Coastal Flood

- Sea level rise + subsidence of cities on river deltas, e.g. New Orleans, Shanghai

Wildfire

- Fire, smoke and ember damage to properties, business downtime

Earthquake

- Earthquake shaking destroy properties, extensive infrastructure damage and disruptption

Chronic Risks

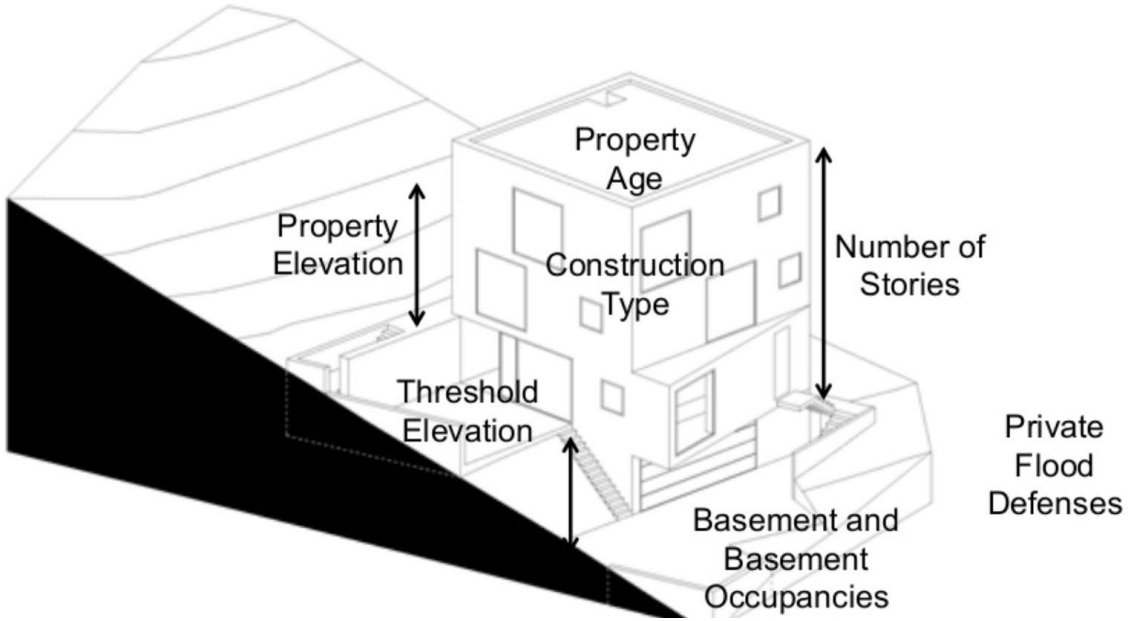
Water stress

Heat stress

- Impacts on business production, increased costs

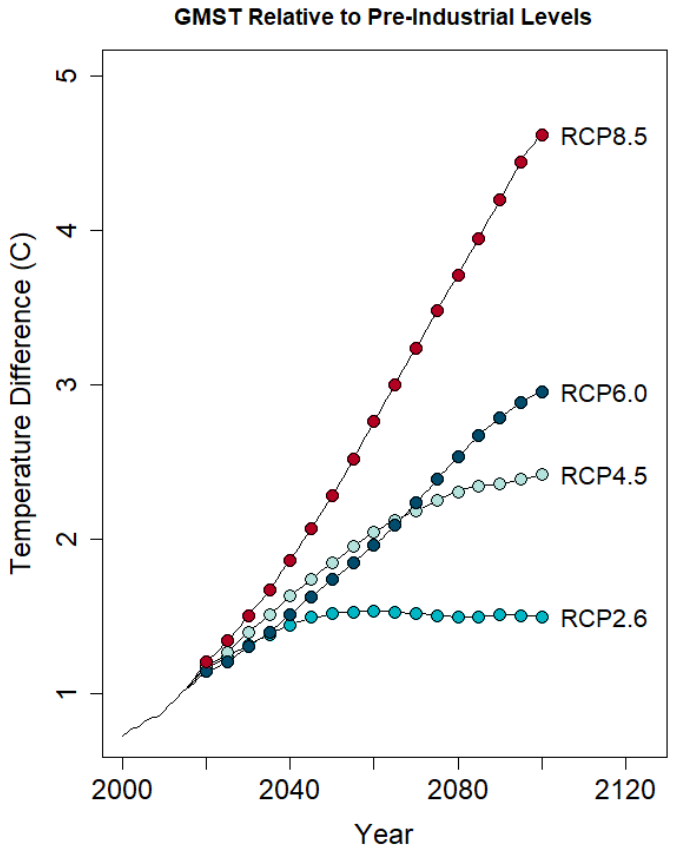
Understand How Different Assets React

- Account for local **differences in building practices** and codes
- **Engineering-based** approach to vulnerability
- **Validation** against $100s billions of damage data



Fort Myers Beach FL, following HU Ian in 2022 (credit State University of New York, Prof Michel Bruneau)

Scenarios: Pathways not Snapshots



Global Mean Surface Temperature (GMST) increase relative to pre-industrial (1880-1900) levels																	
	Year																
	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
RCP2.6	1.2	1.2	1.3	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
RCP4.5	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.0	2.0	2.1	2.2	2.3	2.3	2.3	2.4	2.4	2.4
RCP6.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.0	2.1	2.2	2.4	2.5	2.7	2.8	2.9	3.0
RCP8.5	1.2	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.8	3.0	3.2	3.5	3.7	3.9	4.2	4.4	4.6

NGFS Central Banks and Supervisors Network for Greening the Financial System

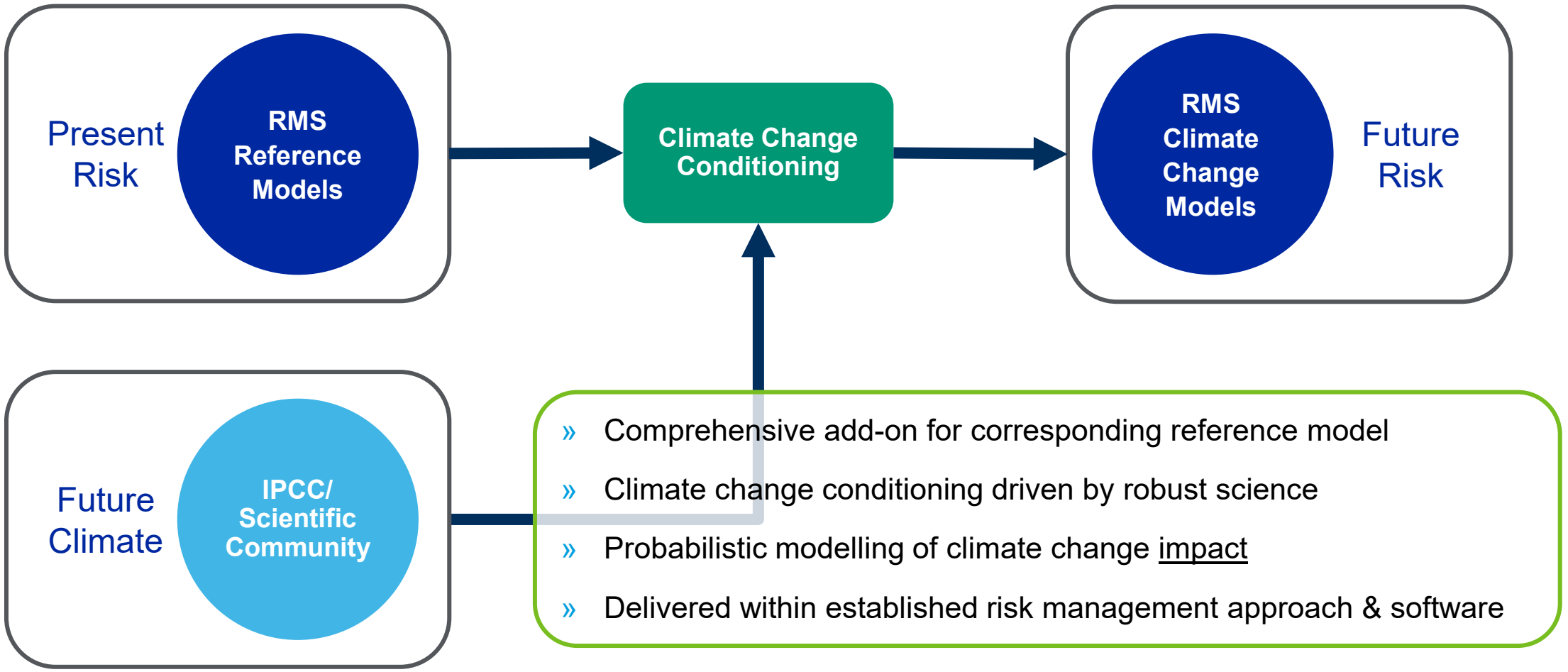
BANK OF ENGLAND PRUDENTIAL REGULATION AUTHORITY

PARIS2015 UN CLIMATE CHANGE CONFERENCE COP21·CMP11

TCFD TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES

Other Physical Risk Scenario

Climate Change Models



Data to Inform Climate Risk Modeling

Building Characteristics

Geocode

Hazard

Insurance Coverage

Event Response

3

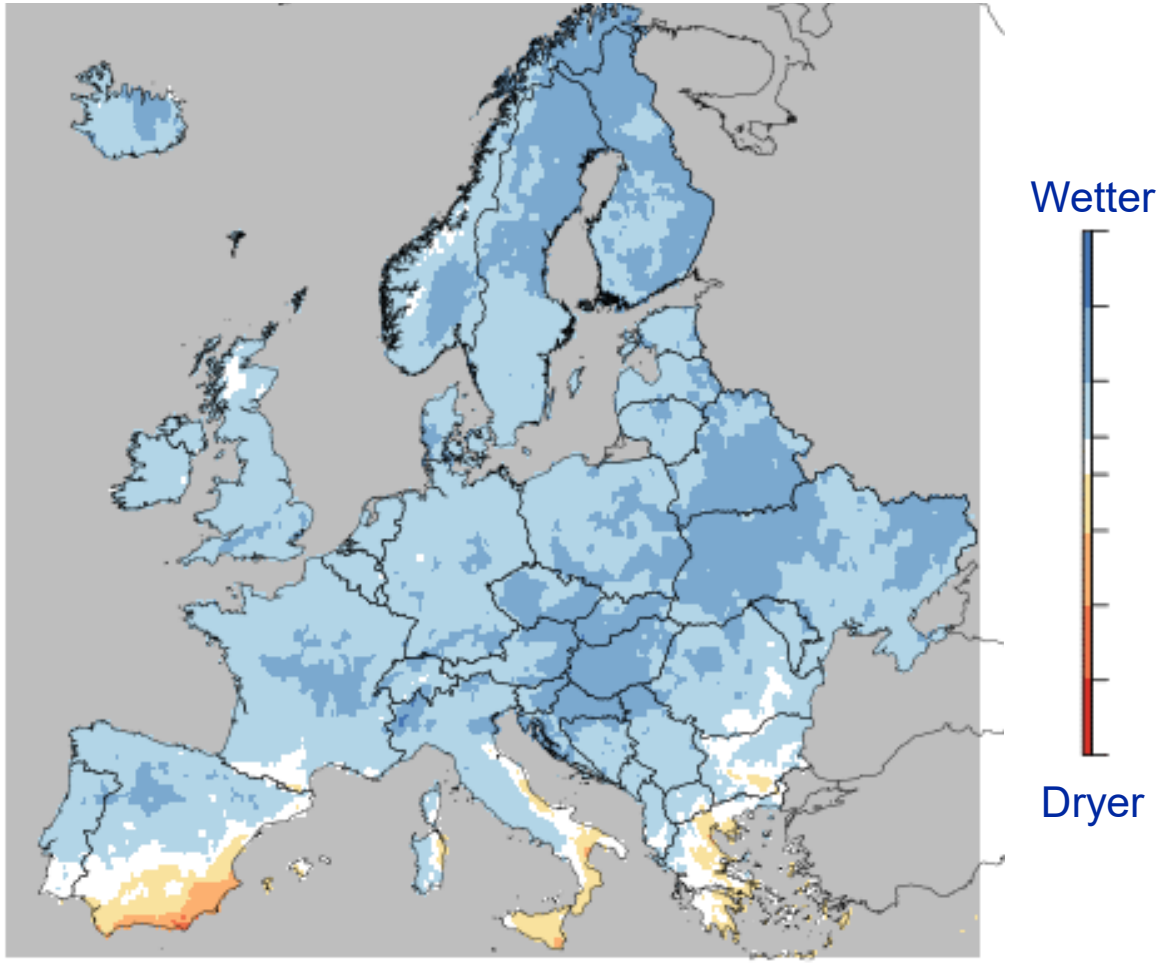
Climate Change Impacts on UK Flood Risks

Climate Change Impacts on Flood Risk

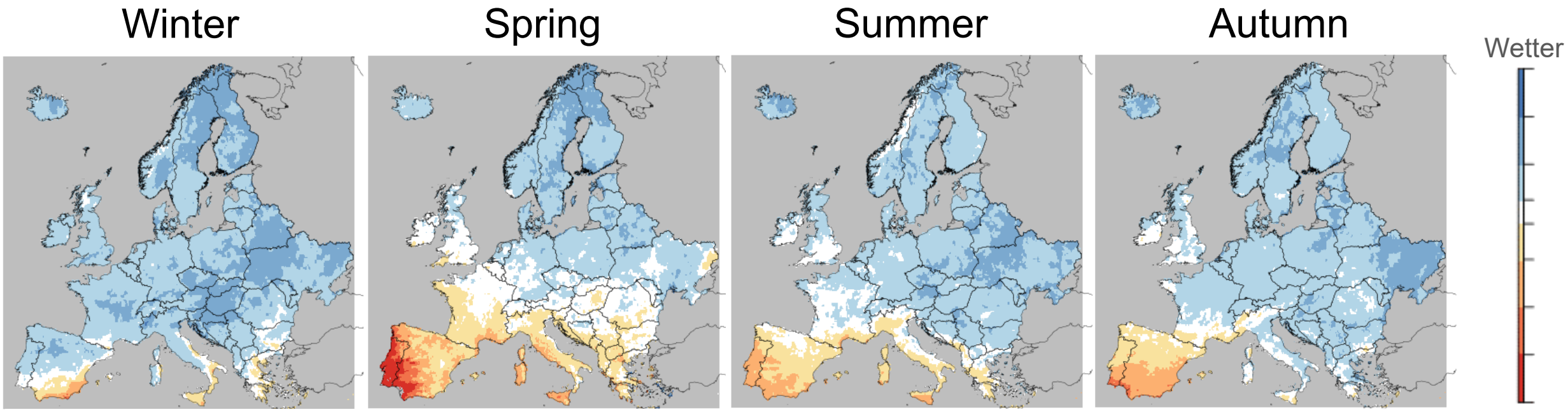
- **Changes in specific humidity and rainfall**
  - A warmer atmosphere can hold more water vapour
- **Changes in atmospheric circulation**
  - Shift in winter storm tracks, or shifts in the Hadley circulation
- **Changes in evaporation**
  - Increase in evaporation over the ocean and wetland areas vs evaporation over land
- **Different changes in different regions & seasons**

Winter

Change in Daily Extreme Precipitation: RCP4.5 2041–2070 vs. Present



Climate Change Impacts Are Complex



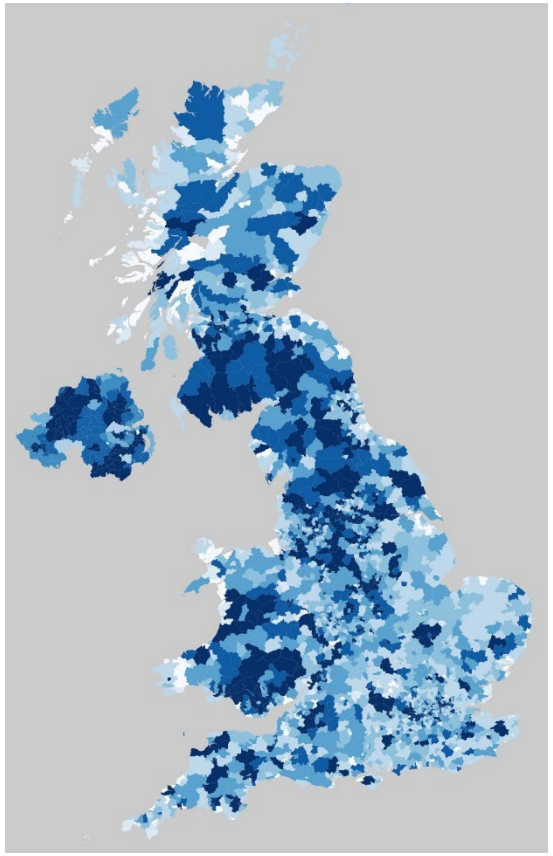
Seasonal Change in Daily Extreme Precipitation: RCP4.5 2041–2070 vs. Present

Source: EURO-CORDEX data

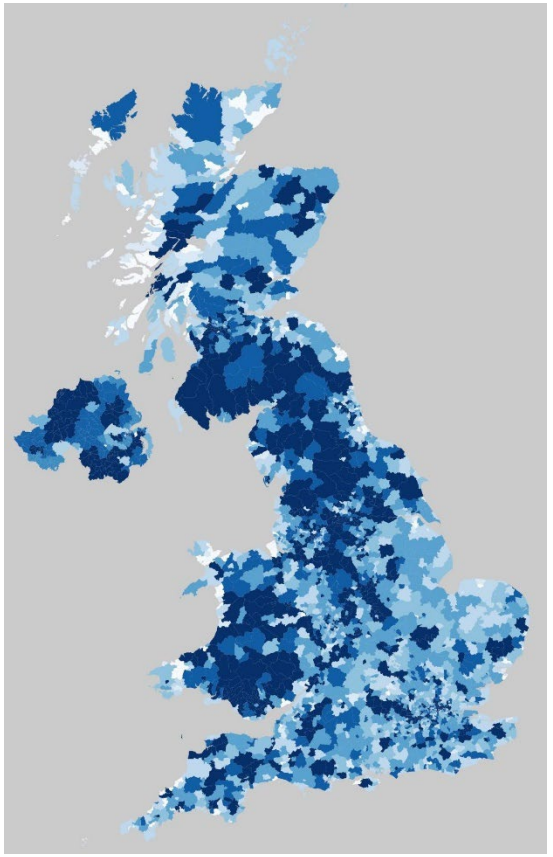
Regional-Level Average Annual Damage

One time horizon: 2050
One RCP scenario: RCP8.5

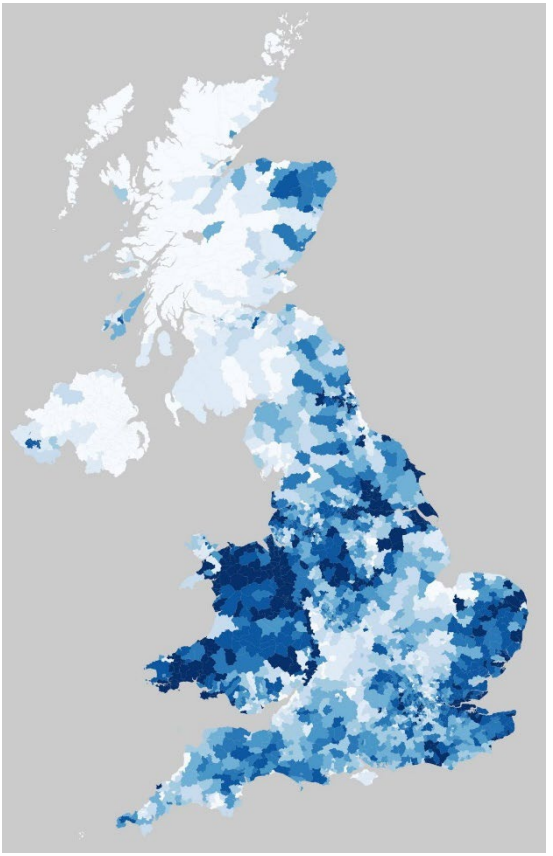
AAD: Present Day



AAL: RCP8.5 2050

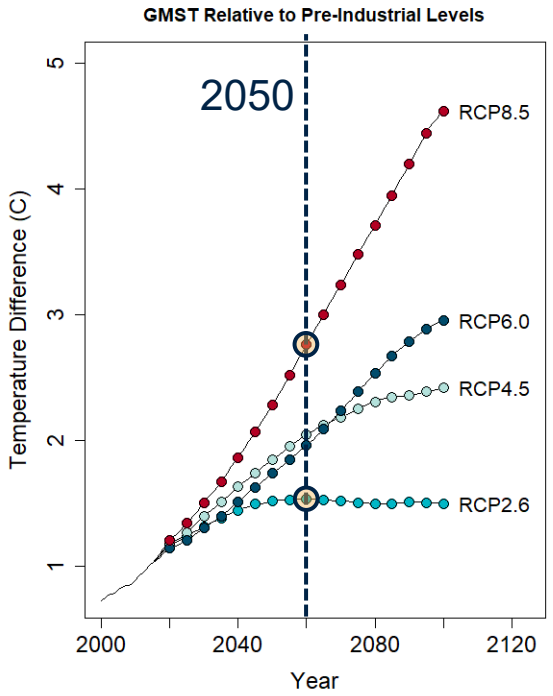


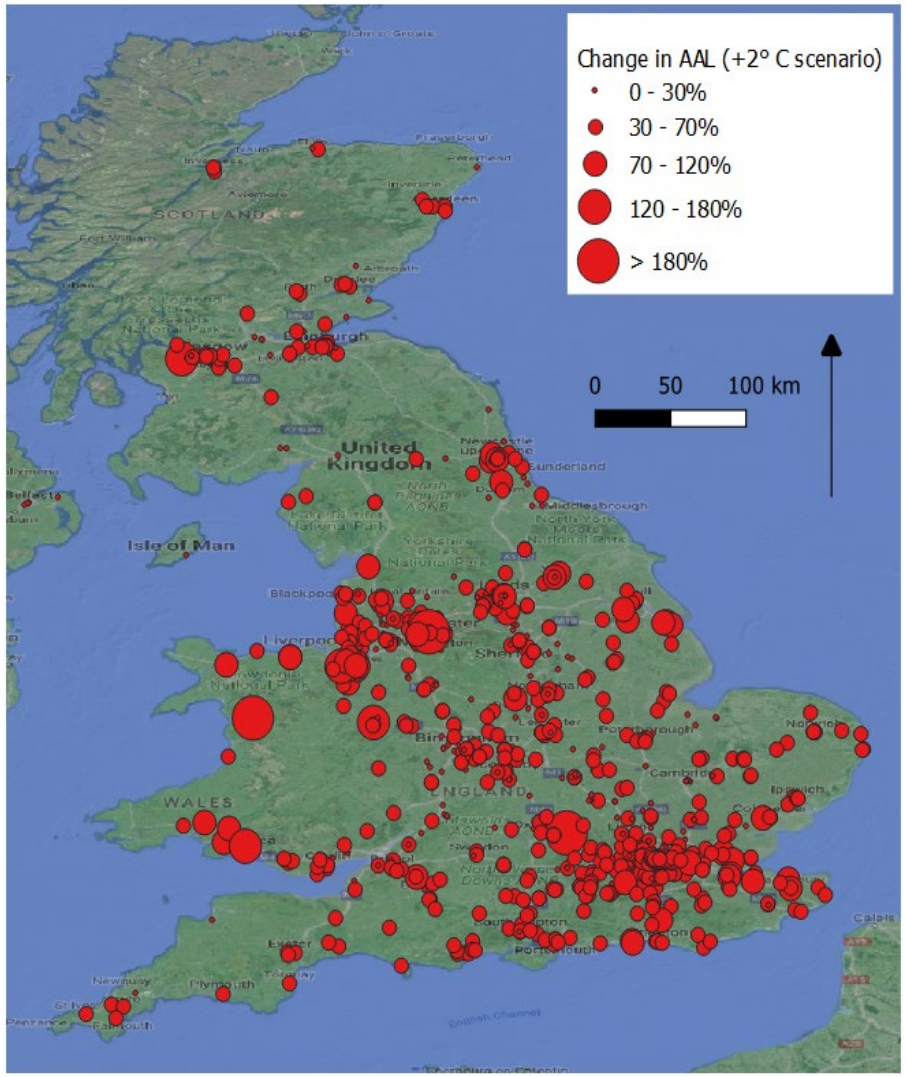
% Change



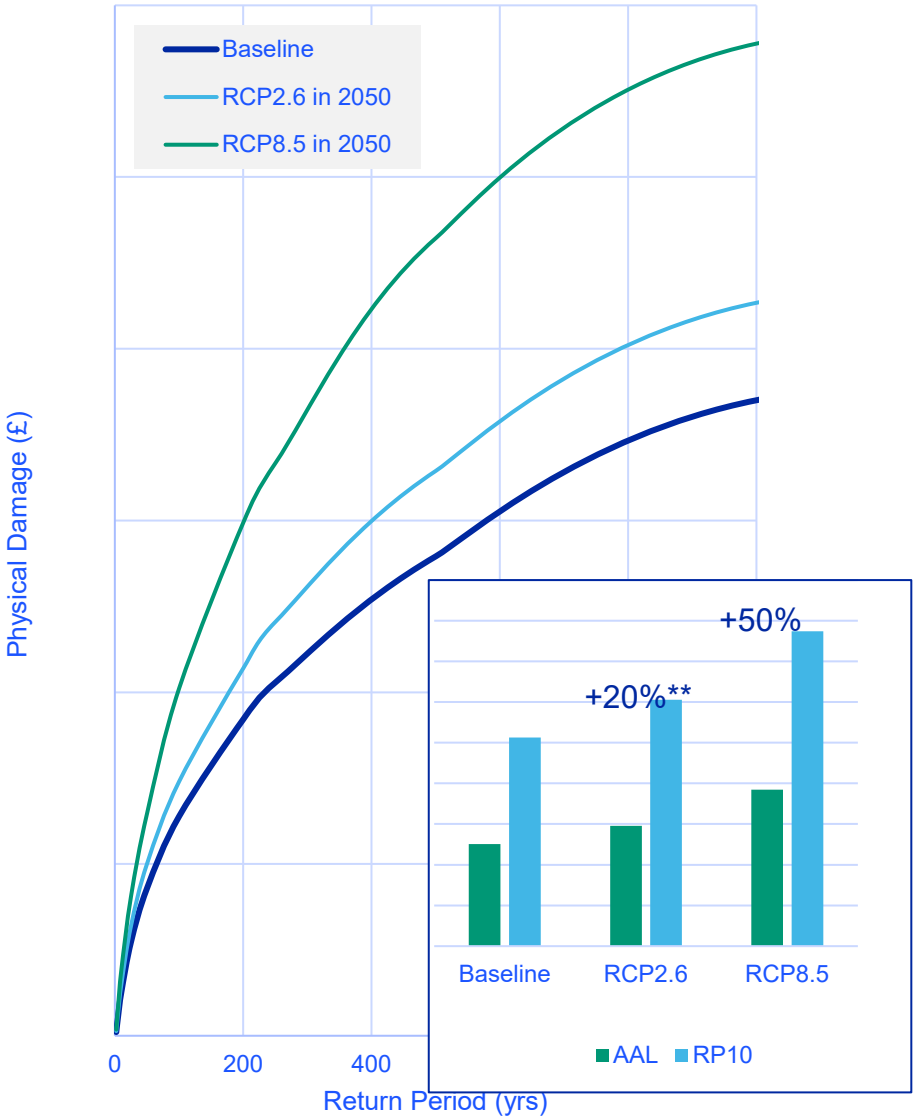
Case Study

Portfolio and location metrics for current risk and two scenarios (RCP2.6 and 8.5) in 2050





Portfolio damage EP curve



** Note: % change from baseline, rounded to nearest 10%

Climate Stress Tests Scenario Support

- Climate scenarios include RCP4.5 & RCP8.5 at 2050 for key climate shocks: wind, flood, wildfire
- Fully probabilistic modelling approach enables meaningful analysis of return periods and selection of appropriate events in line with severity requirements
- Flexible modelling capabilities allow for native consideration of insurance coverage terms within the model

Modelling process

1. **Data collection & augmentation:** Collect client data on asset locations, characteristics, and insurance coverage terms. Augment and enhance data as necessary.
2. **Materiality analysis:** Conduct initial analysis to identify high-risk hazards and regions
3. **Event selection:** Identify events in the RMS stochastic catalogue which meet shocks published by regulators
4. **Physical risk modelling – part 1:** Derive collateral structural damage caused by each scenario
5. **Physical risk modelling – part 2:** Translate damage into collateral credit risk impacts (PD, LGD)

Integrating Physical Climate Risk into Credit Risk

Location Specific Physical Climate Risk

Business Interruption (Indirect)

Expected Loss
Standard Deviation
Loss Distribution

Acute Asset Damage (Direct)

High-Risk Properties

- Local Damage Updated House Price Index
- Updated NOI and Value by Property

Climate Adjusted Credit Risk

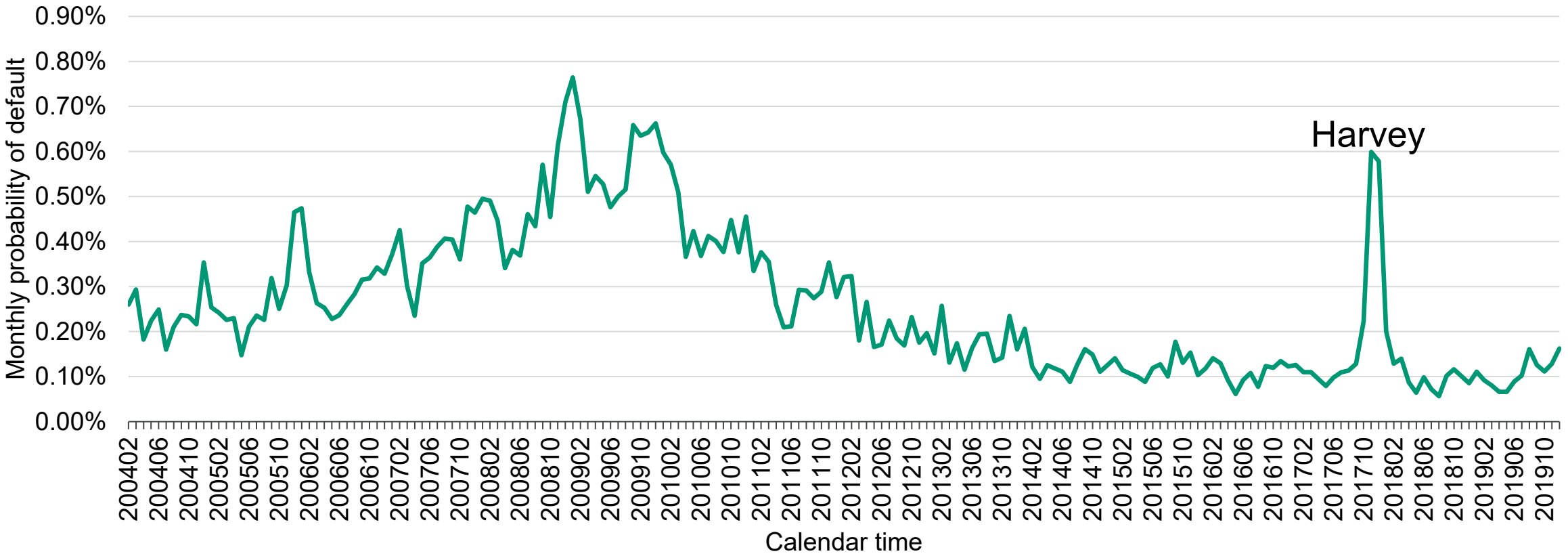
- Probability of Default
- Loss Given Default
- Expected Default Frequency
- Risk ratings

4

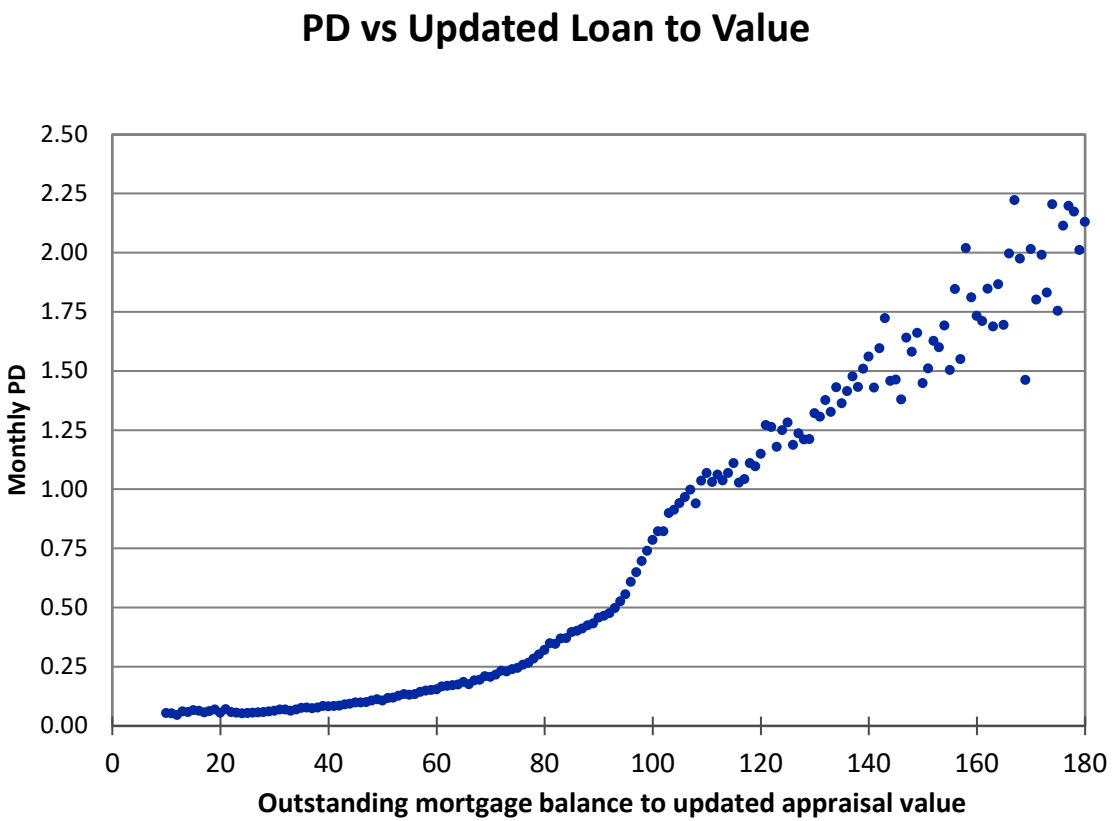
Incorporating flood hazard forecasts in credit mortgage analytics

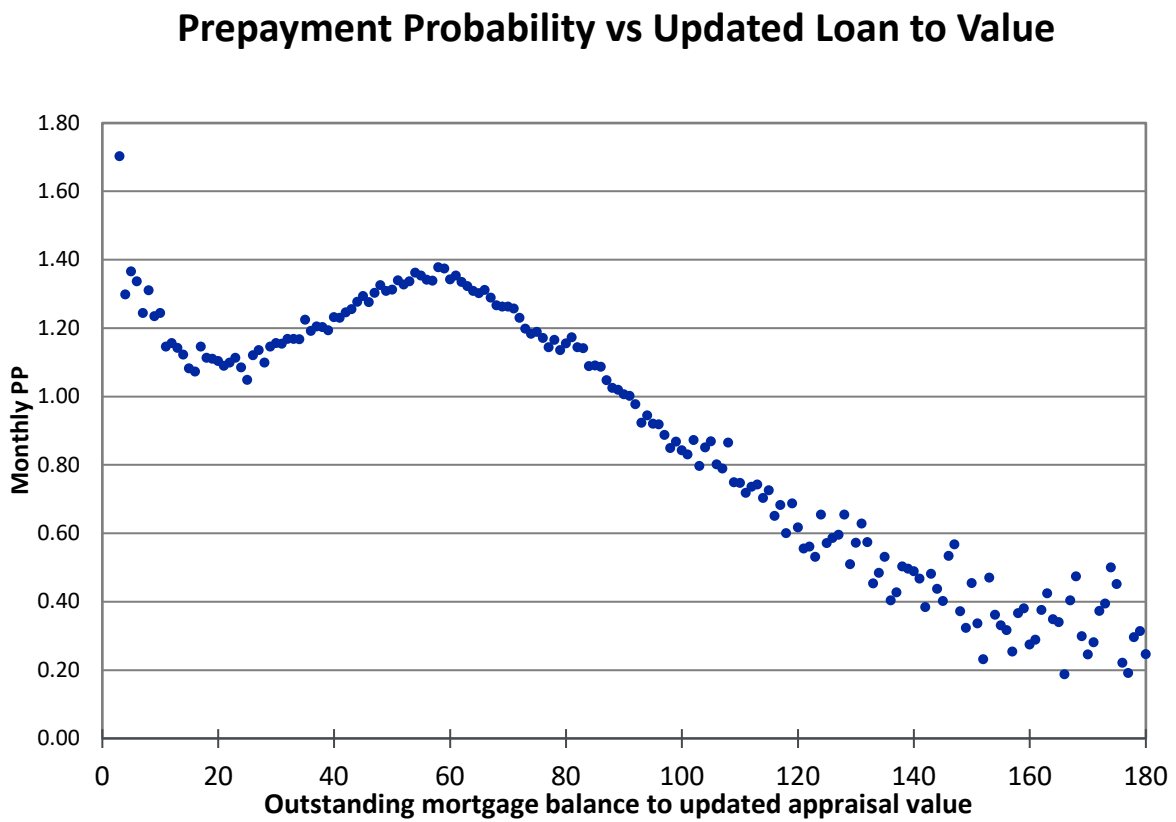
Hurricane Harvey in Texas

Mortgage (first lien fixed) default rate in Texas

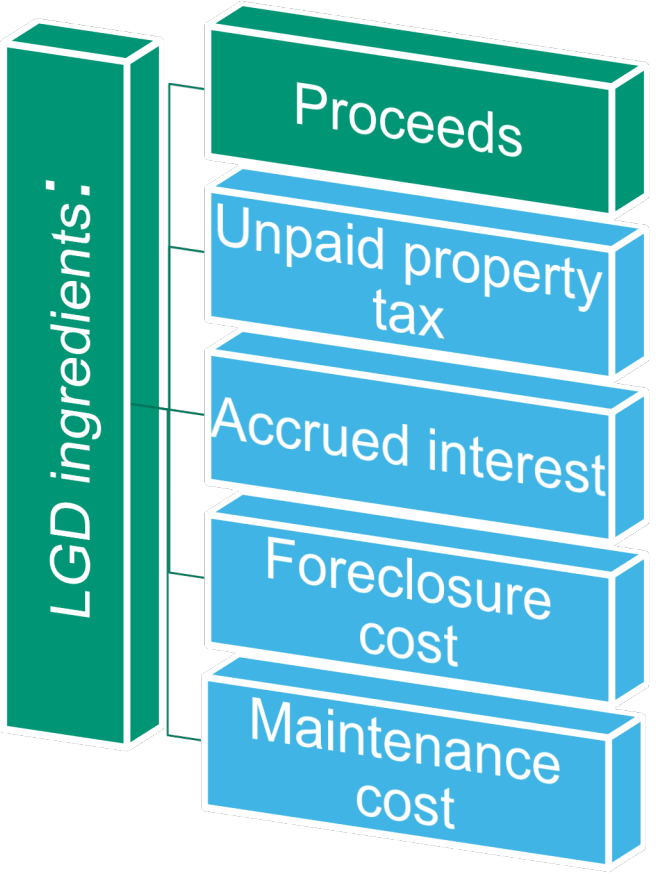


Updated Appraisal Value is the Main Driver of PD and PP



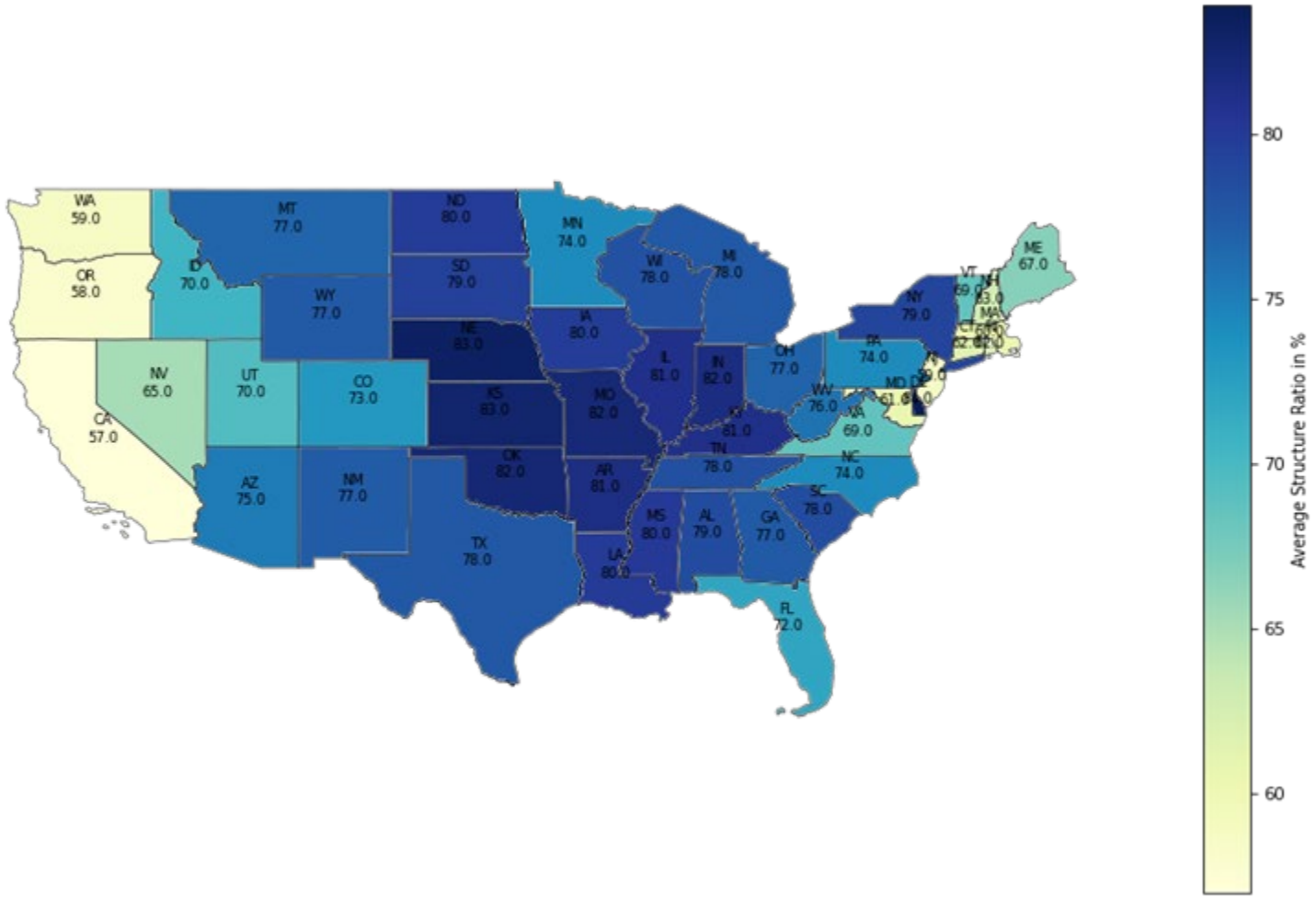


Updated Appraisal Value is the Main Component of Loss Given Default(LGD)



Property value = Land Value + Structure Value

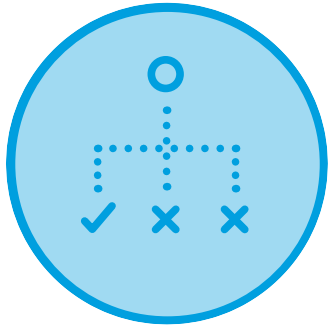
Distribution of Average Ratio of Structure Value of Single Houses



From Physical Risk to Credit Risk

Simulation of Flood Events

50,000 events considered, occurring over a 1Yr period. Total property exposure and resulting damage for impacted locations.



Event Selection

Analysis is focused on the more extreme portion of the event distribution

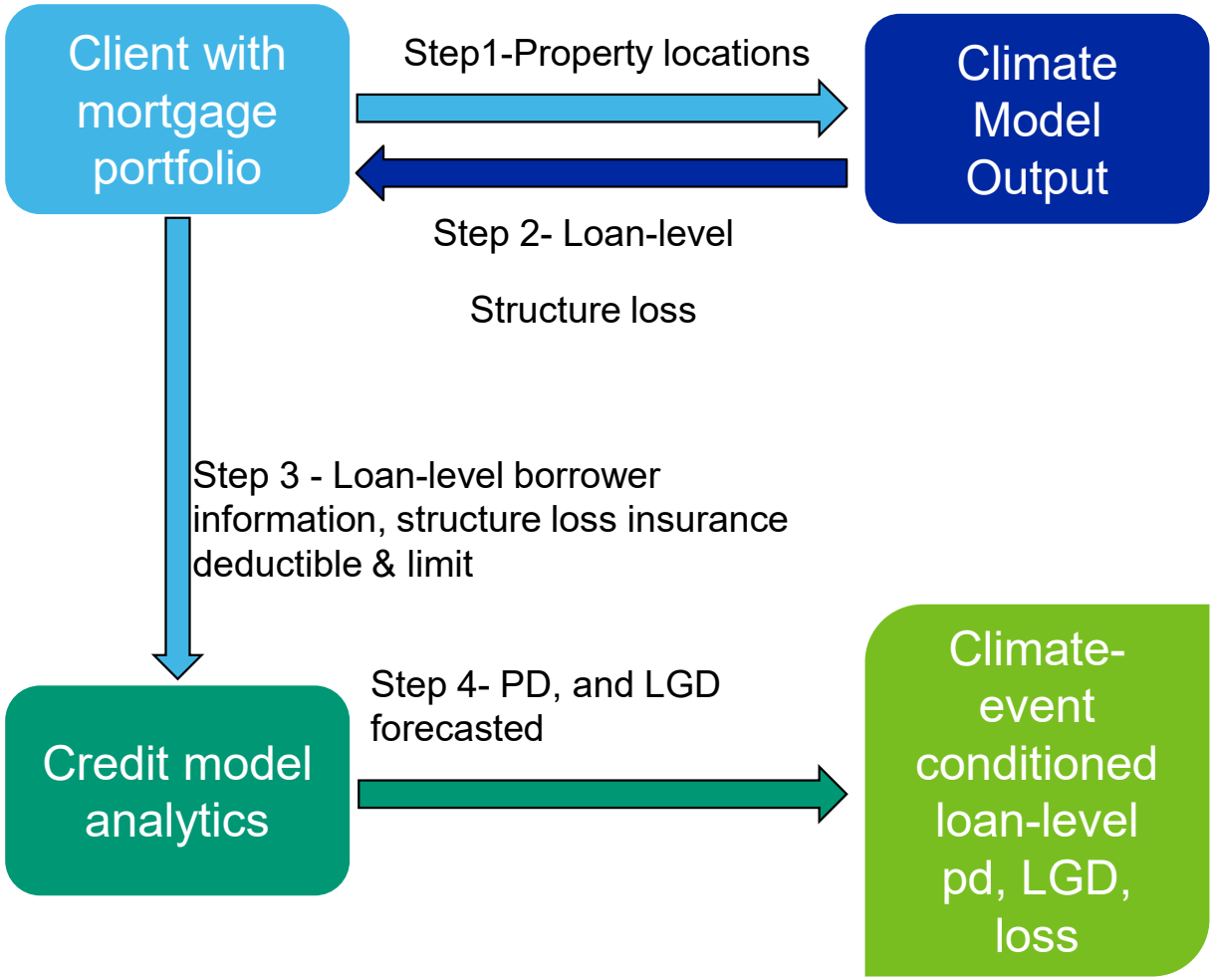
Local Damage Updated Collateral Value

Within each event, there is a set of impacted locations/properties.

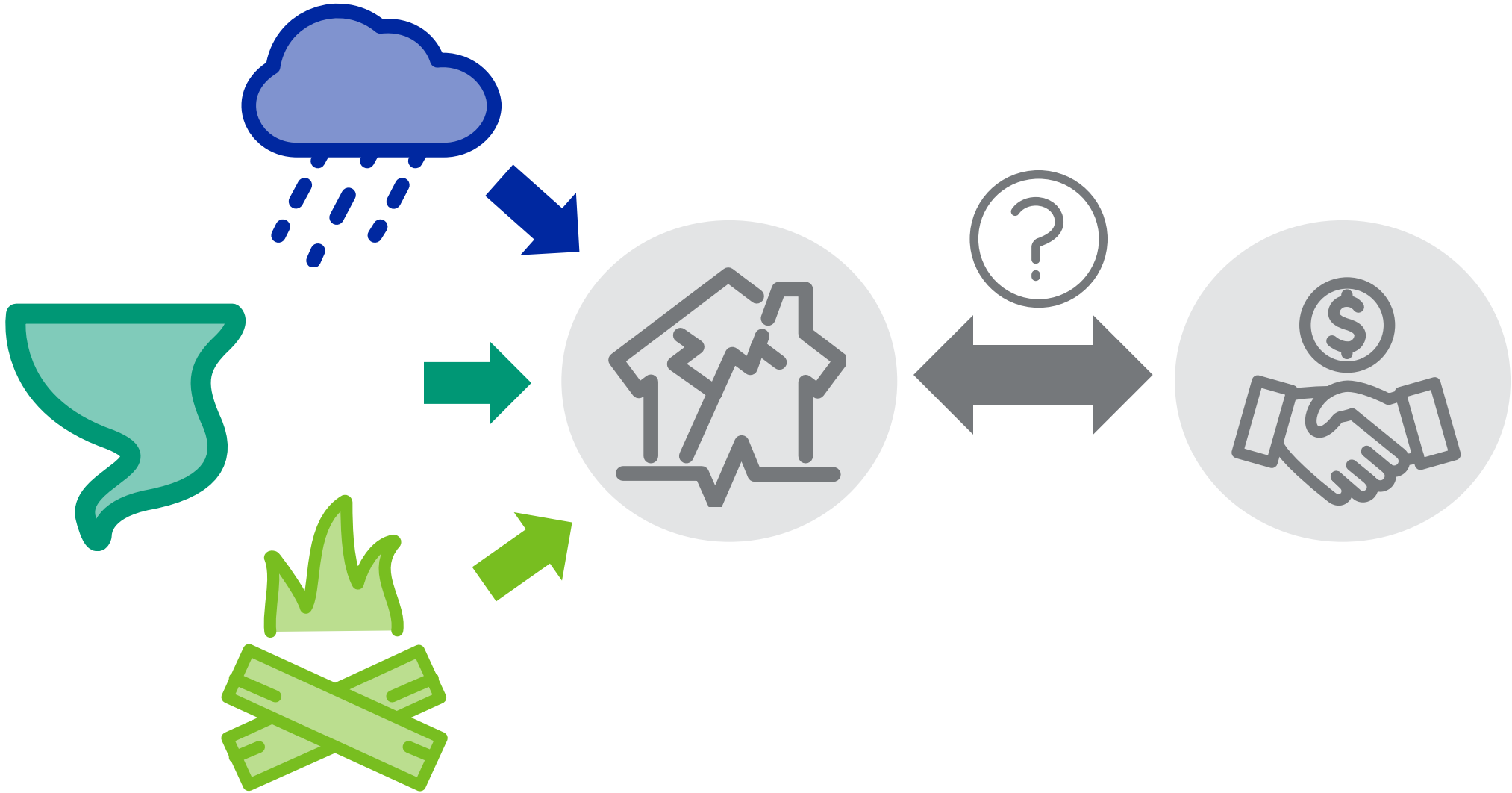
Credit Risk Assessment

The updated appraisal value in the aftermath of the climate event feeds credit risk assessment

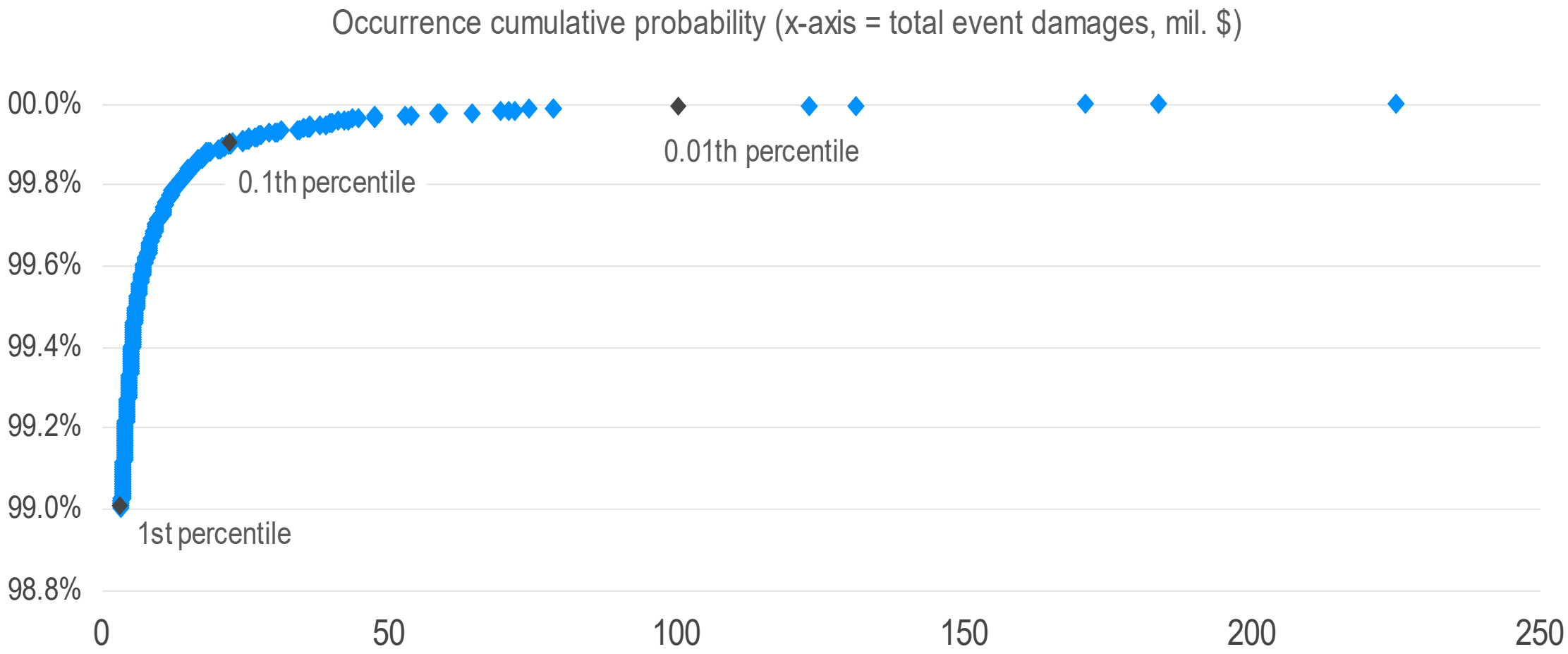
Workflow – Mortgage Analytics and Climate Model Integration



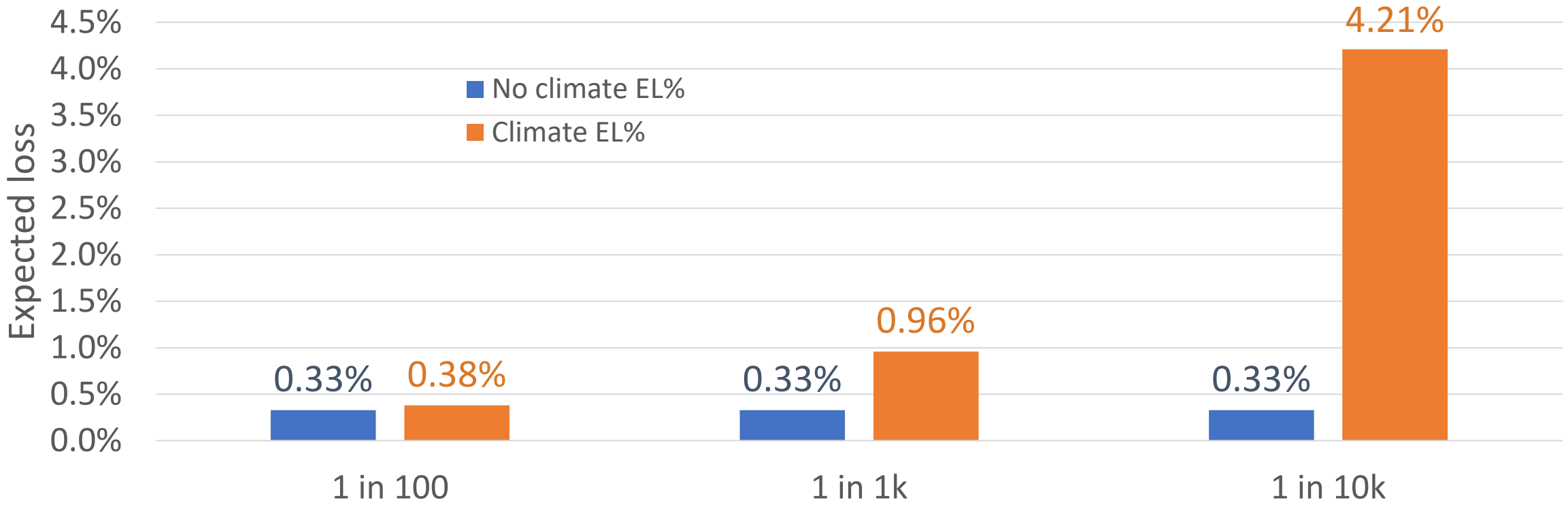
The role of insurance



Flood Simulation for a Portfolio of 1356 Locations ($900M total structure value) in Florida



Expected Losses for the Three Scenarios



Takeaways

Embedding physical climate risk analytics into credit models

Measuring the impact of extreme natural disasters on a mortgage portfolio

Utilize home insurance to mitigate the impact of natural disasters on credit losses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