Moody's Analytics

SUSTAINABILITY IN FOCUS

Climate Hazard Modelling: Impact of Floods on Credit Risk for the U.K. Mortgages

July 8, 2021

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Today's Speakers

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Moody's Climate Solutions

Forward-looking exposure metrics and risk analytics

Climate Risk Identification

Physical Risk Data

Forward-looking data capturing exposure to climate hazards for: 5,000 listed companies (10,000 by end of 2021) with 2.5m corporate facilities globally; 17m commercial real estate properties in the US; and global sovereigns. On-demand scoring is available.

Transition Risk Data

Assessments of 5,000 companies (10,000 by end of 2021) to identify transition risk exposure from different fossil fuel resource types and power generation technologies. On-demand scoring is available.

Climate Governance

Assessments of 5,000 companies' climate risk disclosures and their ability to seize opportunities presented by climate change.

Climate Risk Quantification

Macroeconomic Scenarios

Climate-adjusted macroeconomic forecasts with an 80-year horizon. Fully aligned with the Network for Greening the Financial System's (NGFS) representative scenarios for physical and transition risk.

Climate-Adjusted PDs

Climate-adjusted probability of default (PD) for listed and unlisted companies powered by Moody's award-winning Expected Default Frequency (EDF™) model.

Climate Pathway Scenarios

Tools that translate climate pathways into financial risk variables to inform asset allocation and liability models. Based on Moody's award-winning scenario generation software.

Agenda

1. Climate change and credit risk quantification framework: The case of mortgages
2. Moody's ESG Solutions' location-specific physical climate risk scores for the U.K.: Floods, heat stress, hurricane and typhoons, sea level rise, water stress, and wildfires
3. Do flood events affect probability of default for mortgages?
4. Constructing score-adjusted climate change scenarios and climate-adjusted credit risk metrics
5. Climate Risk Adjustment

1 Climate change and credit risk quantification framework: The case of mortgages

Polling Question

1. **Have you already made a climate risk adjustment for a mortgage portfolio risk parameters (PD/LGD/Losses)?**

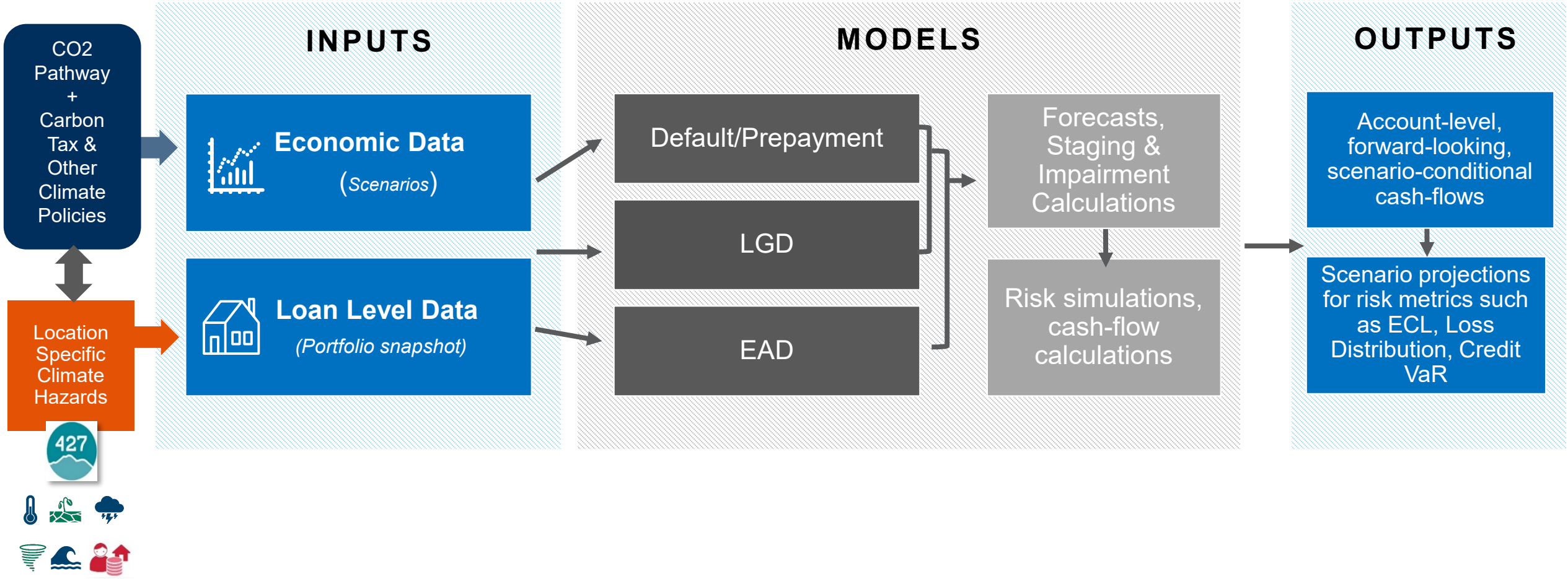
   A. Yes, leveraging on CBES 2021 instructions.

   B. Yes, for a regulatory exercise other than CBES 2021.

   C. Yes, for internal purposes.

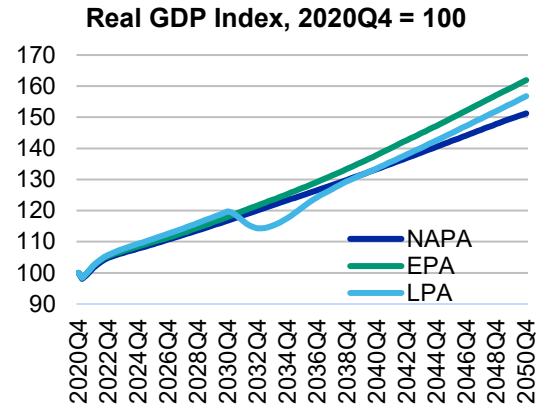
   D. No, not yet.

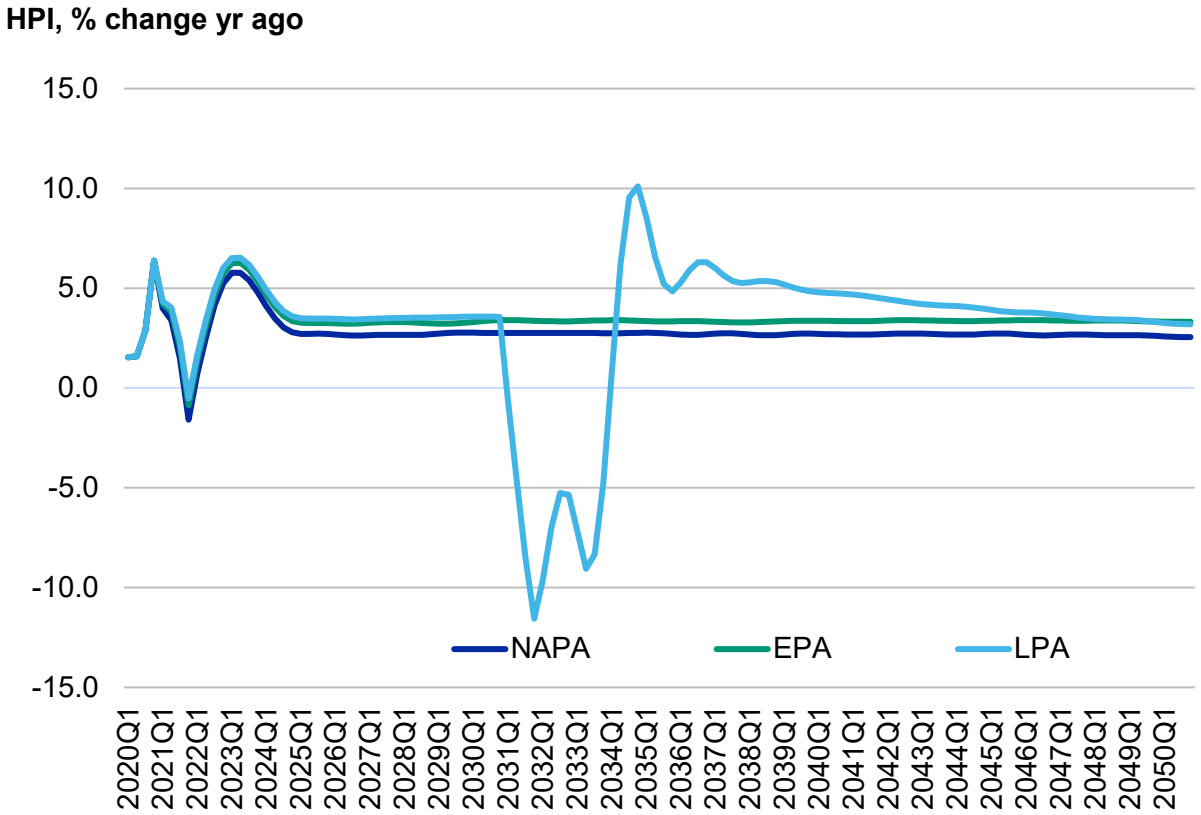
Retail Credit Risk – Enhanced Framework

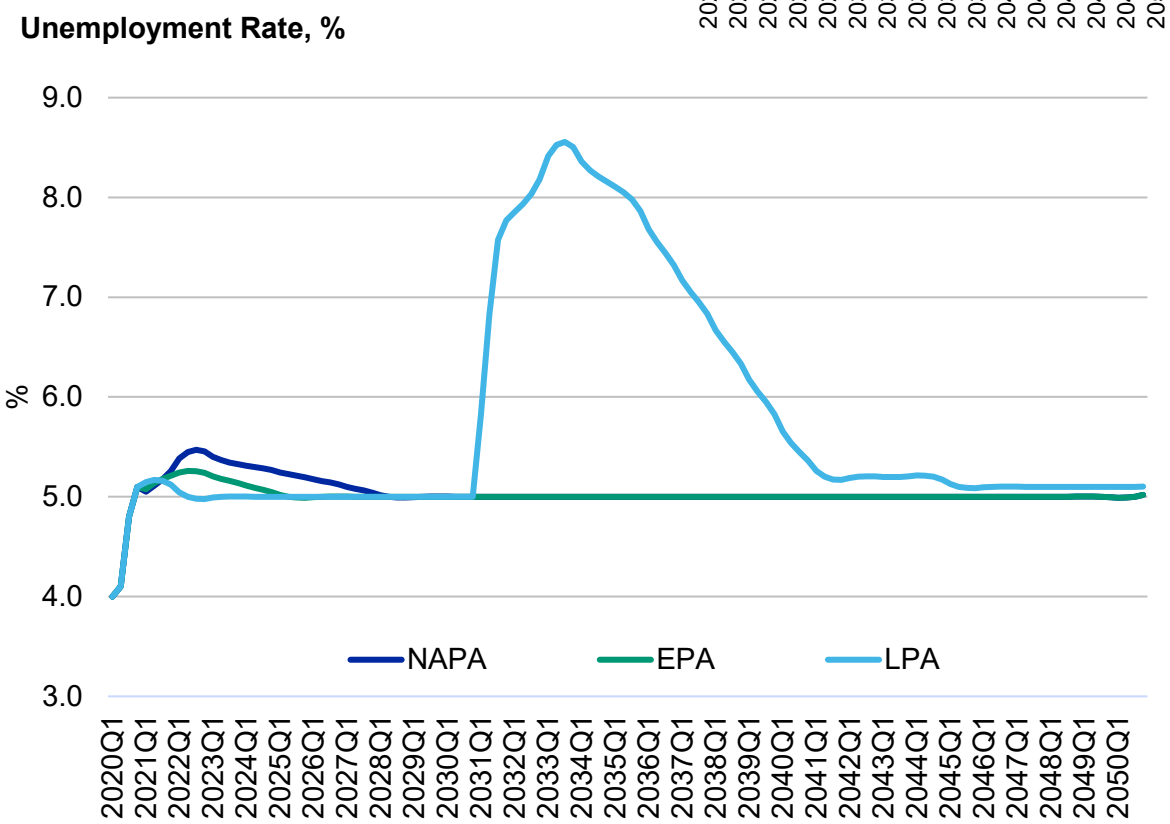


Climate Change Scenarios for the UK

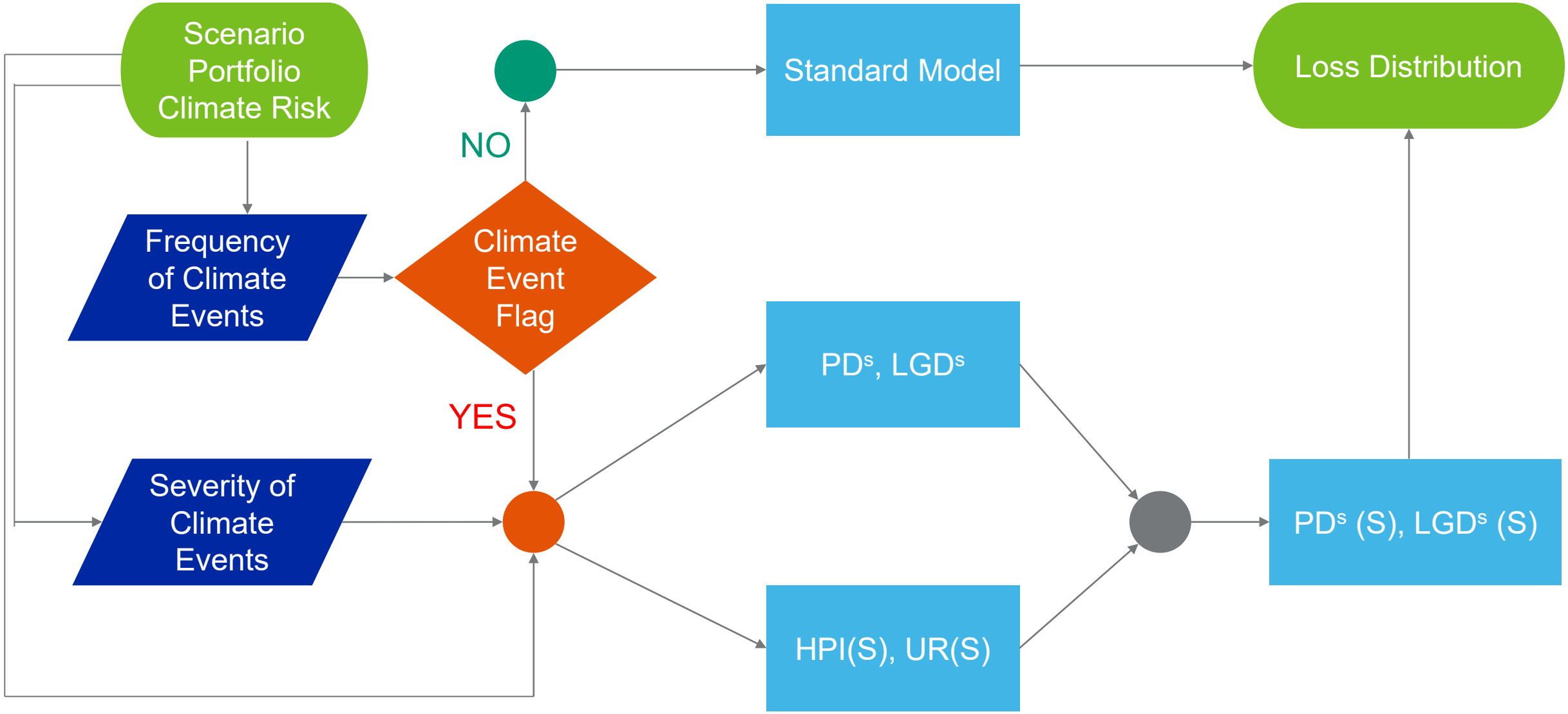
Projections for HPI and unemployment rate







Climate-Adjusted Credit Risk Approach



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Location-specific physical climate risk scores for the U.K.: Floods, heat stress, hurricane and typhoons, sea level rise, water stress, and wildfires

Polling Question

2. What does your firm use physical risk data for?

A. We don’t use physical climate data

B. To help comply with risk disclosure requirements

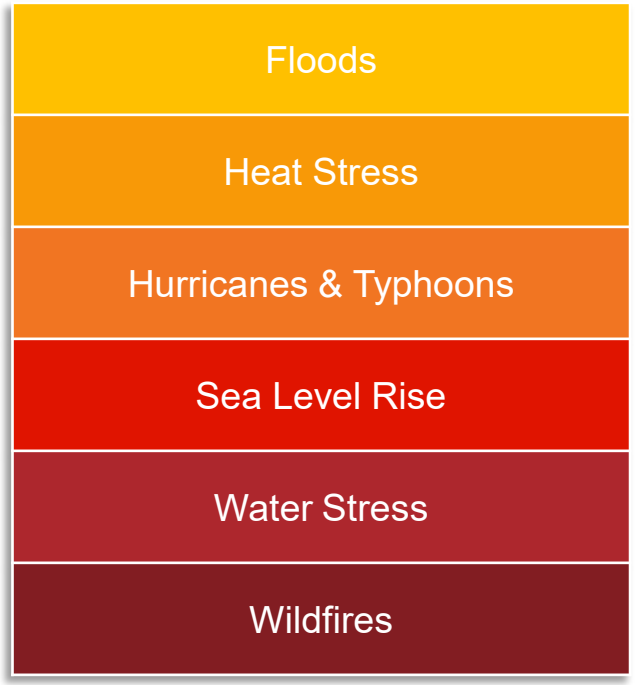
C. Integrate climate risk into pre-acquisition/loan origination

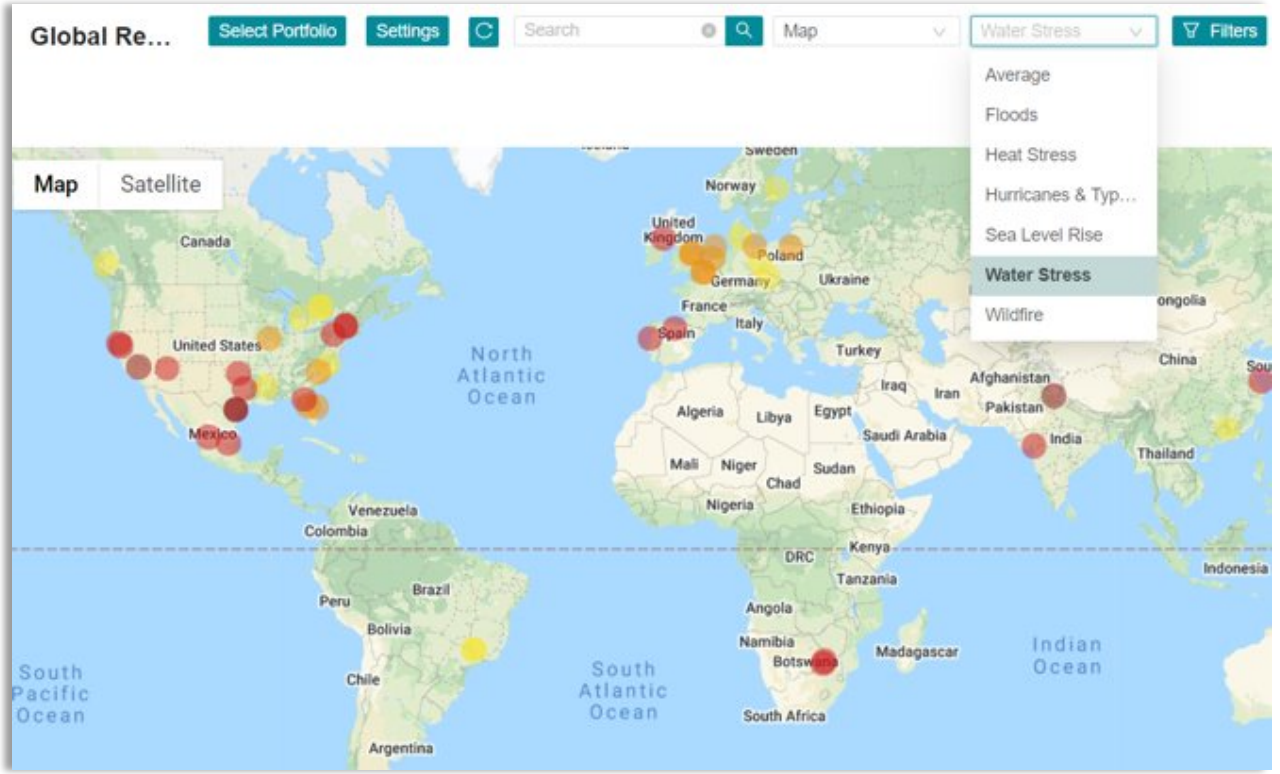
D. Integration into risk management processes/stress tests

E. Multiple uses

Physical Climate Risk for Mortgages

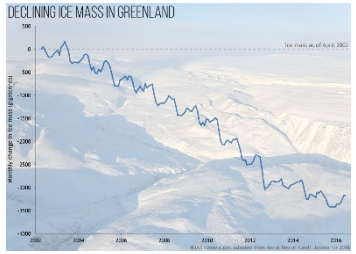
- Based on global climate models & environmental datasets
- Forward-looking scores for each climate hazard
- Detailed underlying indicators



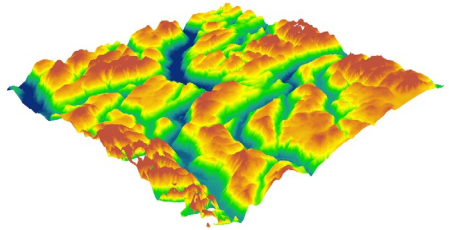


Source: Four Twenty Seven, part of Moody's ESG Solutions

From Climate Data to Risk Scores

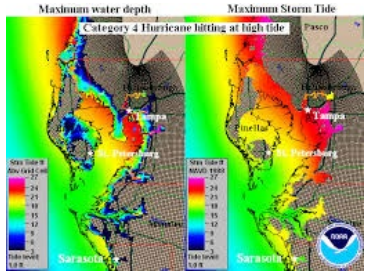


Air, ocean, and ice (including cliff) dynamics

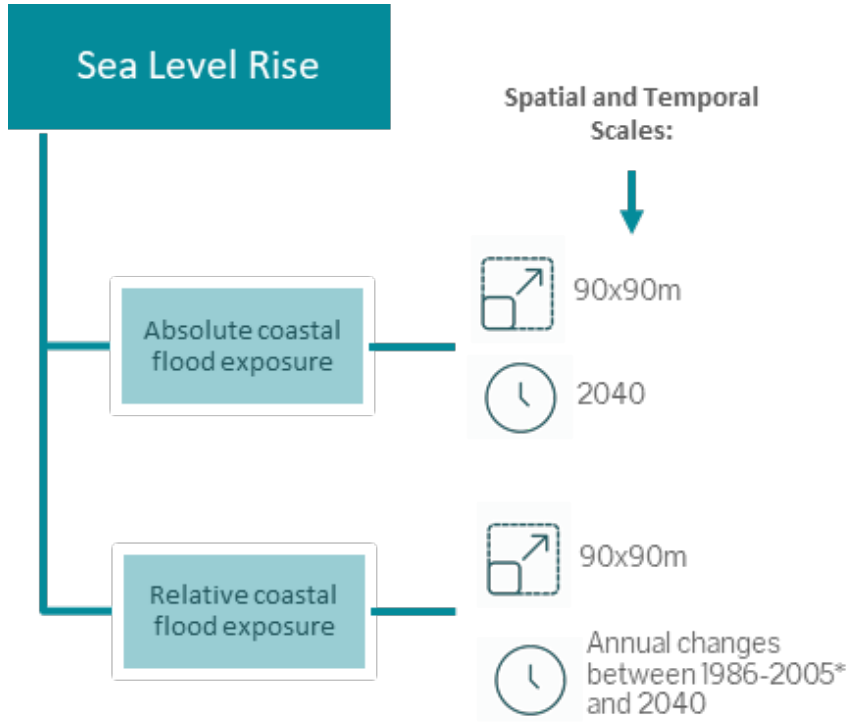


Elevation data (SRTM)

Historical sea levels and subsidence

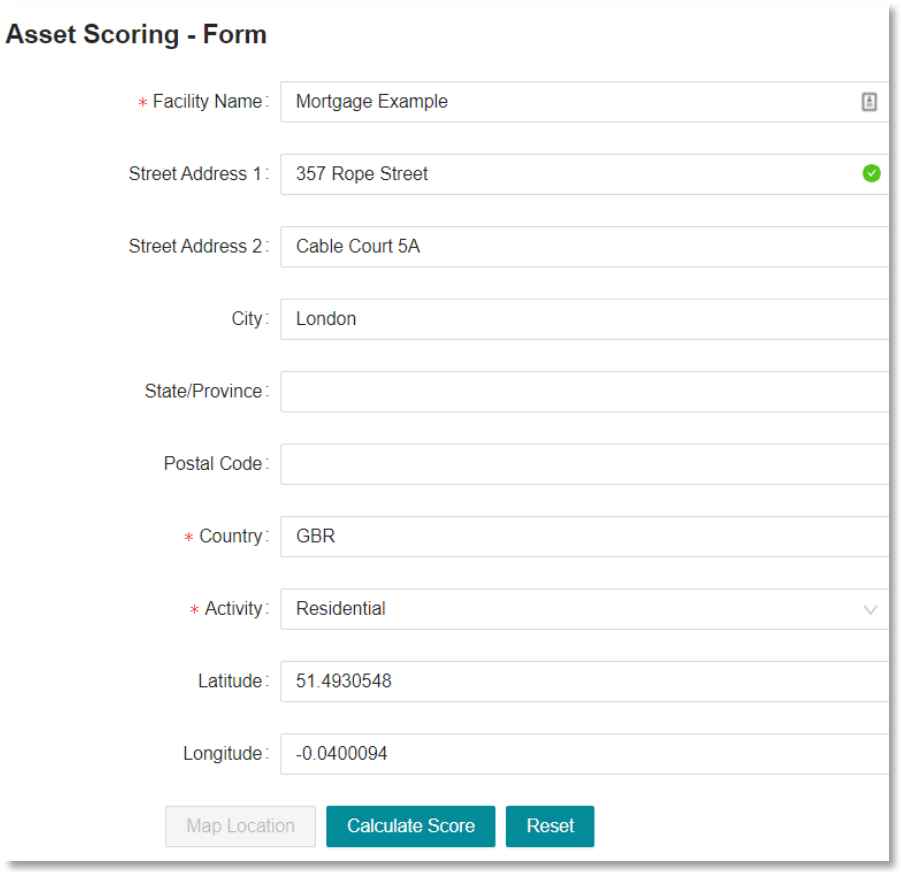


Tidal gauge data for storm surge



Source: Four Twenty Seven

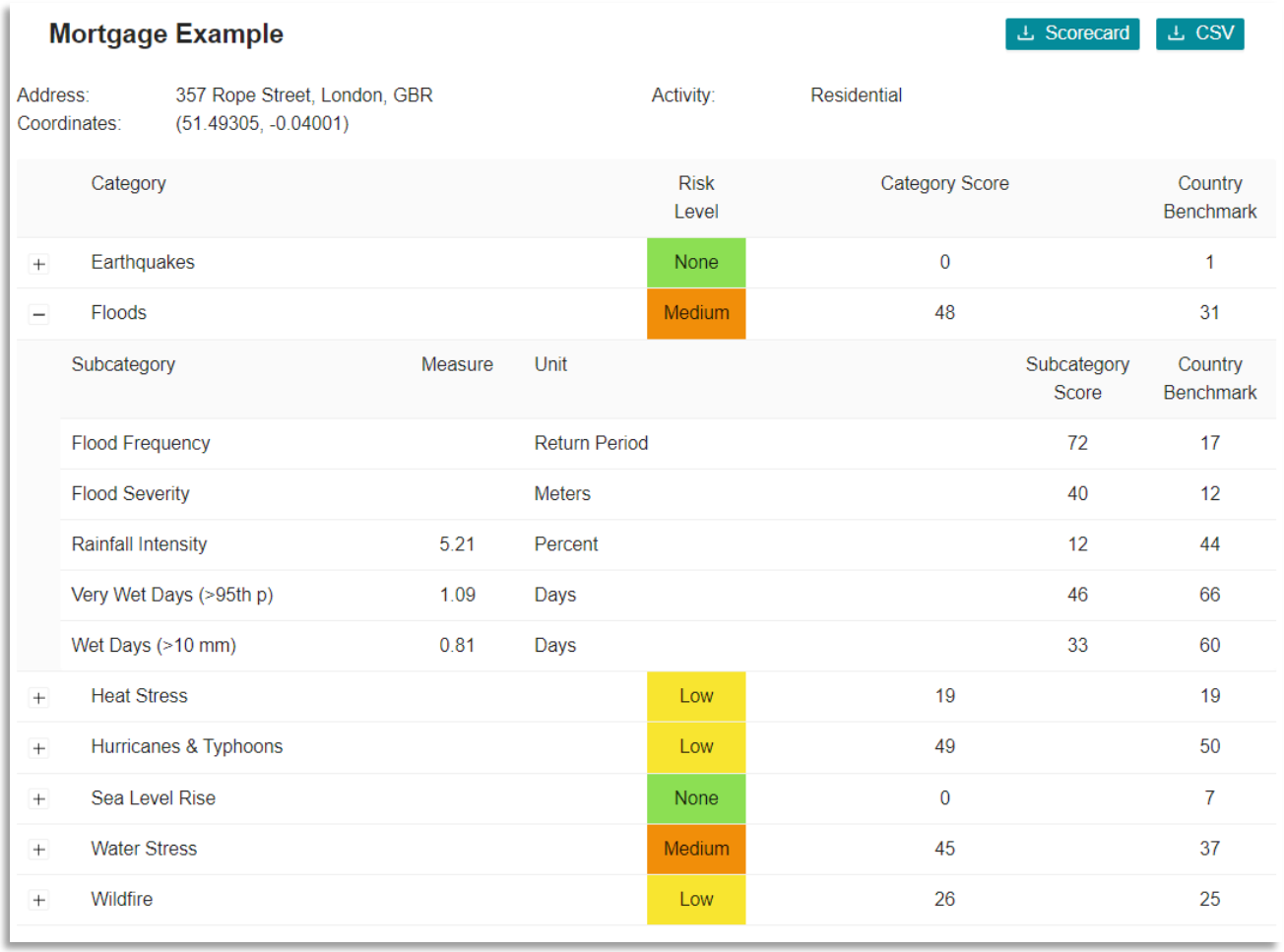
Assessing Climate Risk for a Property



Asset Scoring - Form

* Facility Name:	Mortgage Example
Street Address 1:	357 Rope Street
Street Address 2:	Cable Court 5A
City:	London
State/Province:	
Postal Code:	
* Country:	GBR
* Activity:	Residential
Latitude:	51.4930548
Longitude:	-0.0400094

Map Location | Calculate Score | Reset



Mortgage Example

Scorecard | CSV

Address: 357 Rope Street, London, GBR
Coordinates: (51.49305, -0.04001)
Activity: Residential

Category	Risk Level	Category Score	Country Benchmark
+ Earthquakes	None	0	1
− Floods	Medium	48	31

Subcategory	Measure	Unit	Subcategory Score	Country Benchmark
Flood Frequency		Return Period	72	17
Flood Severity		Meters	40	12
Rainfall Intensity	5.21	Percent	12	44
Very Wet Days (>95th p)	1.09	Days	46	66
Wet Days (>10 mm)	0.81	Days	33	60

+ Heat Stress	Low	19	19
+ Hurricanes & Typhoons	Low	49	50
+ Sea Level Rise	None	0	7
+ Water Stress	Medium	45	37
+ Wildfire	Low	26	25

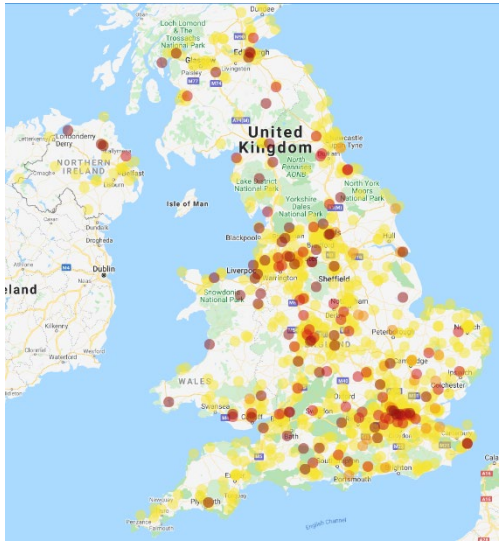
Physical Climate Risk Score

Moody's ESG Solutions Data

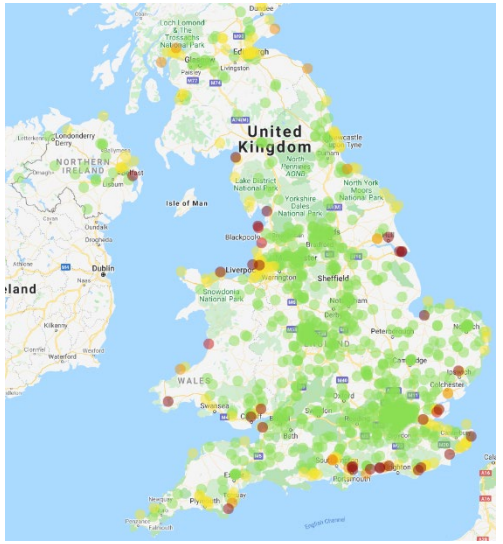
- 1,000 random names of the portfolio and ran the physical risk climate scores within the on-demand scoring application
- **Six climate hazards** assessed at the facility-level: floods, sea level rise, water stress, heat stress, wildfire, and hurricanes & typhons
- Majority of the portfolio is low risk but some material hotspots across specific climate hazards
- While few UK facilities may lead to Red Flags, **UK Floods and Seal Level Risk** scores can easily double or triple, amplifying damages for local economies and assets
- Flood risk followed by Water Stress appears to the be prominent climate hazards affecting the portfolio analysed

UK Sample (1000 facilities)

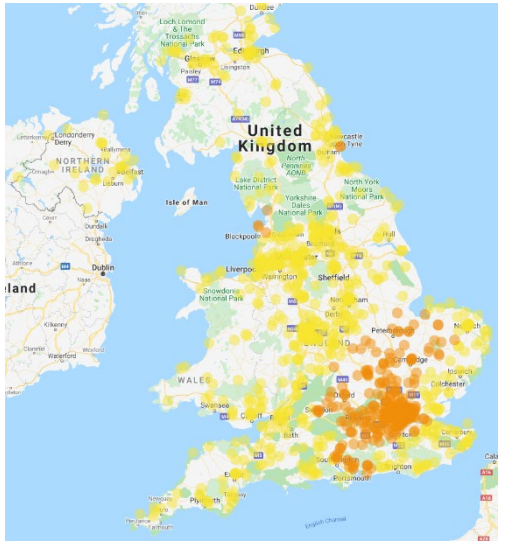
Floods Score



Sea Level Rise Score



Water Stress Score



3

Do flood events affect probability of default for mortgages?

Polling Question

3. What is the expected impact of climate events such as floods on PD for mortgages?

A. The impact is statistically negligible.

B. PD increases by less than 1%

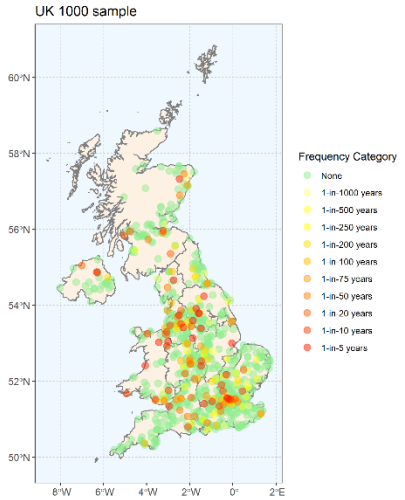
C. PD increases by more than 1%.

Linking Probability of Flood Events to Credit Risk

Flood Frequency Score

Return period of inundation
1-in-5 years
1-in-10 years
1-in-20 years
1-in-50 years
1-in-75 years
1-in-100 years
1-in-200 years
1-in-250 years
1-in-500 years
1-in-1000 years
None

Flood Frequency Categories



Climate Event Simulation Engine

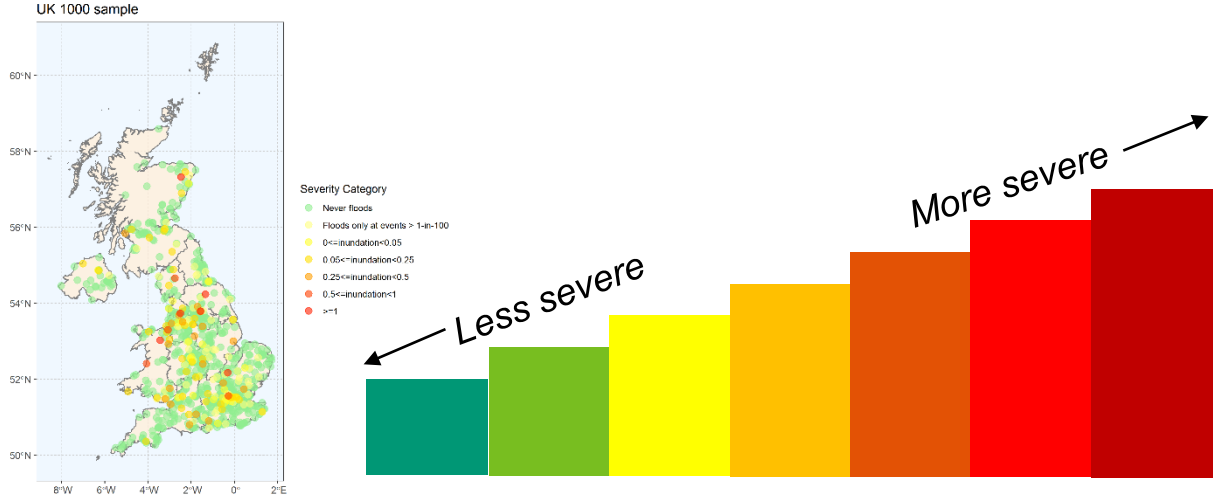
Frequency scores are translated into probability of events based on the property's location.

When will the event occur?

- Impact on macroeconomic drivers (e.g., HPI).
- Impact on credit risk metrics such as PDs & LGDs (idiosyncratic impact).

How severe will the hazard be?

Flood Severity Categories



Climate Adjustment to the PD Model

From standard PD metrics to climate-adjusted PDs

Standard PD model:

$$\ln\left(\frac{DR}{1-DR}\right) = \alpha + \beta X + \varepsilon$$

Account-specific data, macroeconomic drivers

Uncaptured variability: Could it be explained by climate events?

→ *Estimated* $\widehat{DR}$ →

Climate-Adjusted PD model:

$$\ln\left(\frac{DR}{1-DR}\right) = \ln\left(\frac{\widehat{DR}}{1-\widehat{DR}}\right) + \gamma Event + \mu$$

$$Event = \begin{cases} 0 \; if \; region \; is \; not \; flooded \\ 1 \; if \; region \; is \; flooded \end{cases}$$

- Determine affected areas/regions: we analysed impact at NUTS1, NUTS2 and NUTS3 levels for the UK.
- Define flooded vs. partially flooded areas: we explored different levels of % of area flooded (>0%, >20%, >40%, >50%, >60%, >70%, >80%, >90%, 100%).
- Ensure event effect is captured (instead of seasonality effect).
- When is the effect in PD observed?: we analysed the impact 0 to 6 months after the flood event was observed.

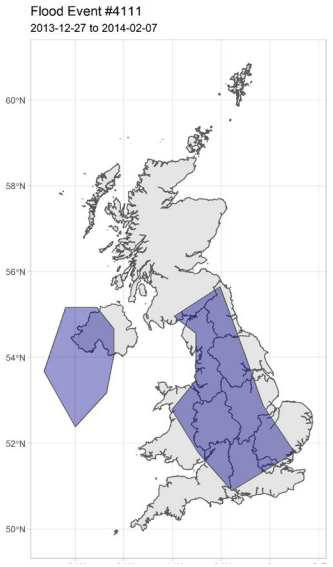
For each event we compute: $$\ln\left(\frac{DR}{1-DR}\right) = \ln\left(\frac{\widehat{DR}}{1-\widehat{DR}}\right) + \gamma Event_{j,NUTSi,p,t+k} + \mu$$

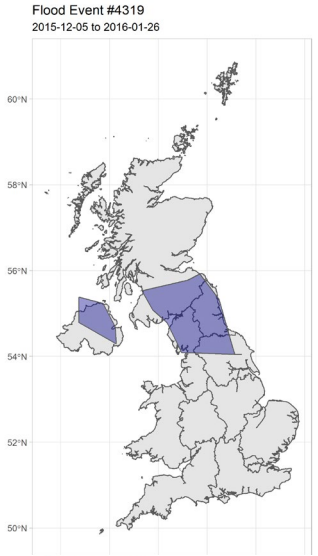
j: specific event
i: NUTS level
p: proportion of area affected by the event
t: time of the event
k: months after the event

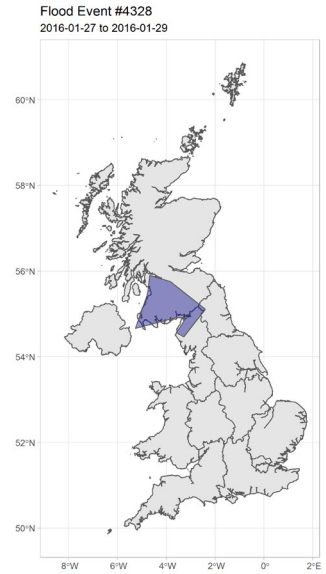
Flood Events Data

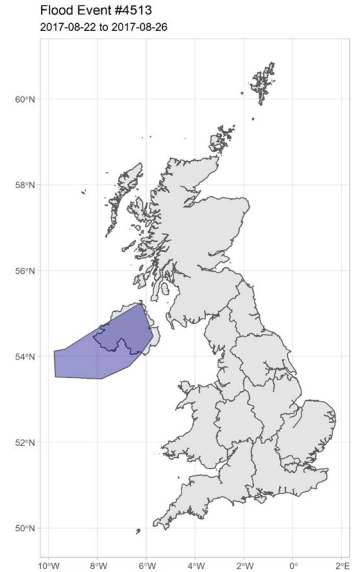
Data related to 74 flood events in the UK from 1989

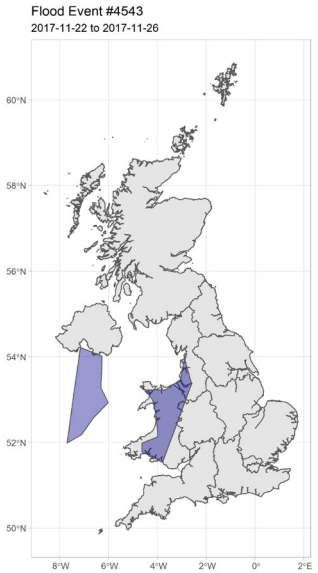
Floods data
Location
Start and End dates
Duration
Severity
Magnitude
Cause (heavy rain, tropical cyclone, rain and snowmelt, torrential rain, storm surge)
Number of casualties
Number of displaces

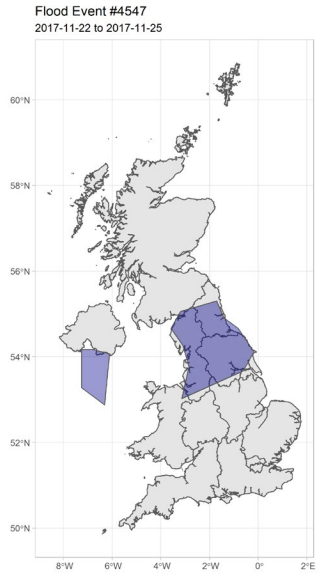


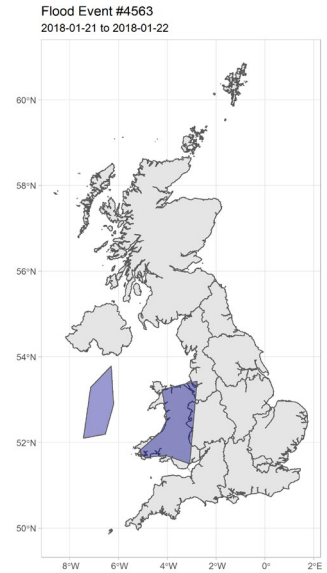


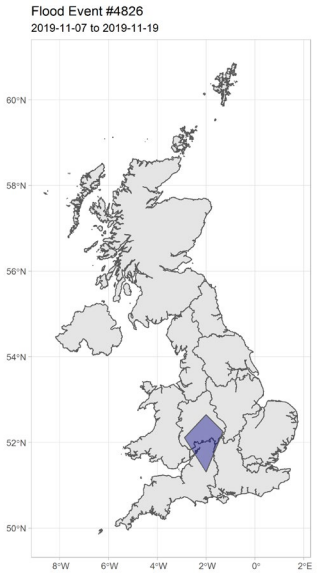






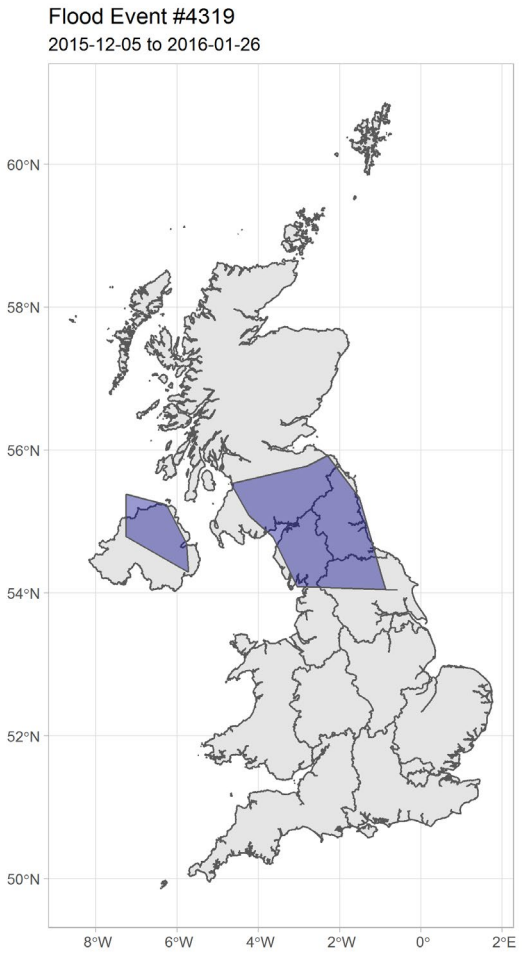


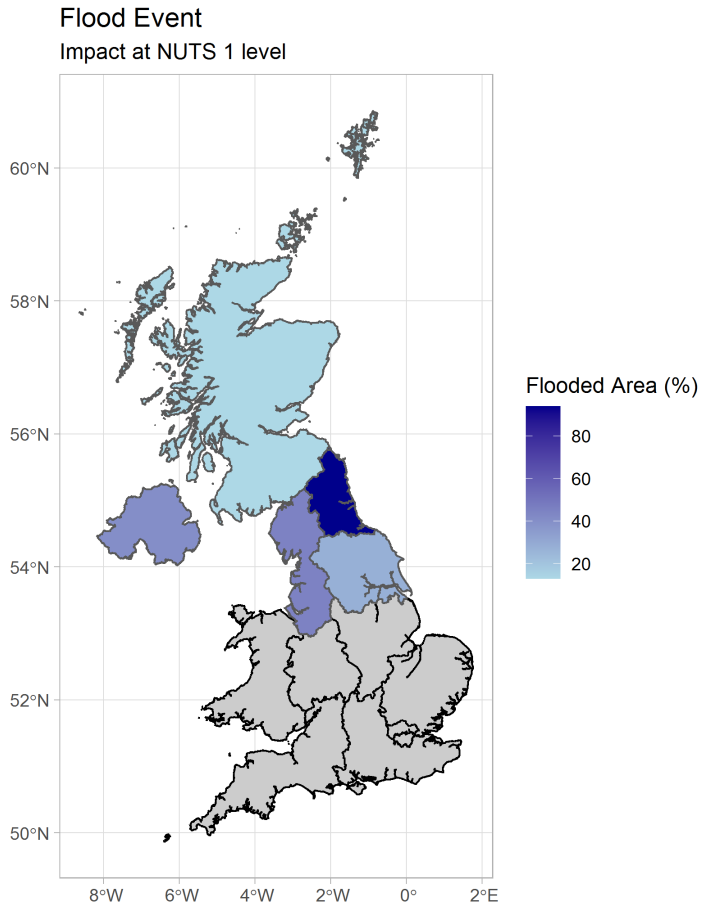


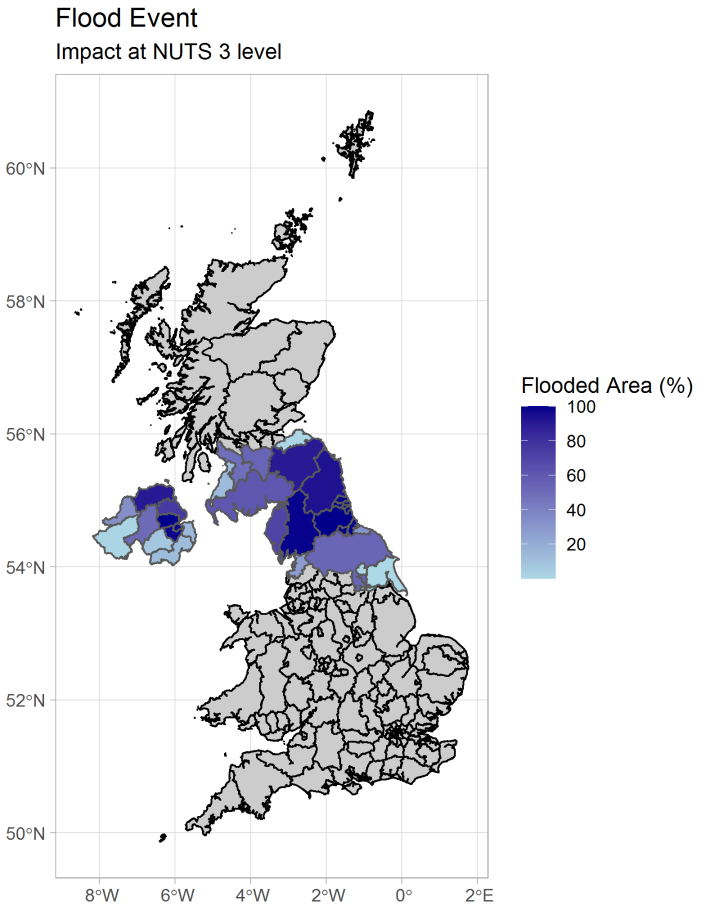


Defining Impacted Areas

Selected example

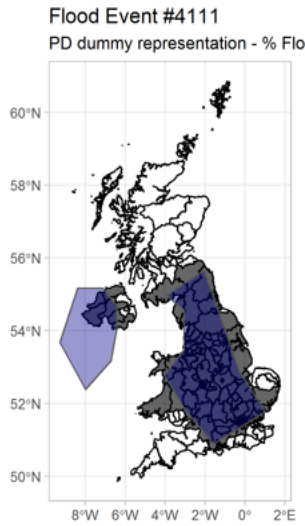




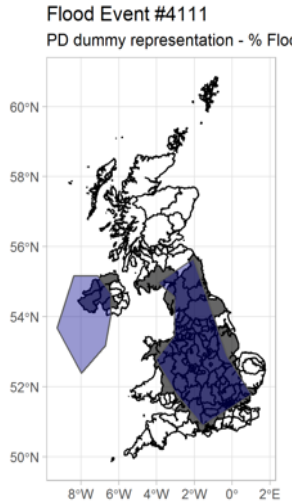


Areas of significant flood events - NUTS3

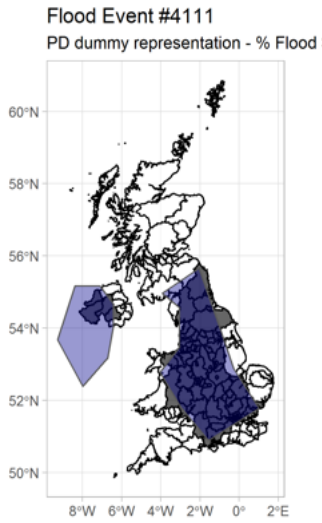
$$\ln\left(\frac{DR}{1-DR}\right) = \ln\left(\frac{\widehat{DR}}{1-\widehat{DR}}\right) + \gamma Event + \mu$$



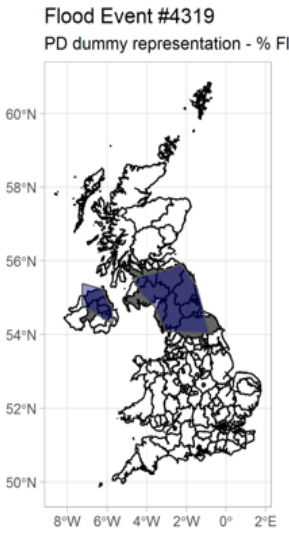
$\gamma = 0.259$



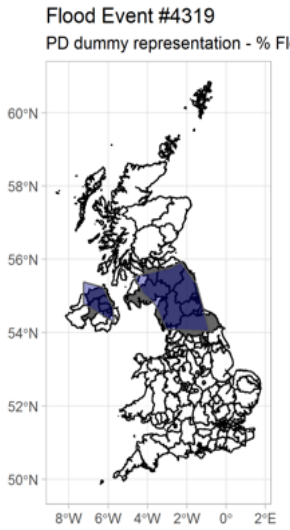
$\gamma = 0.253$



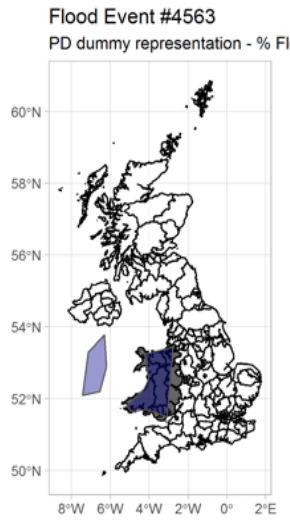
$\gamma = 0.238$



$\gamma = 0.635$

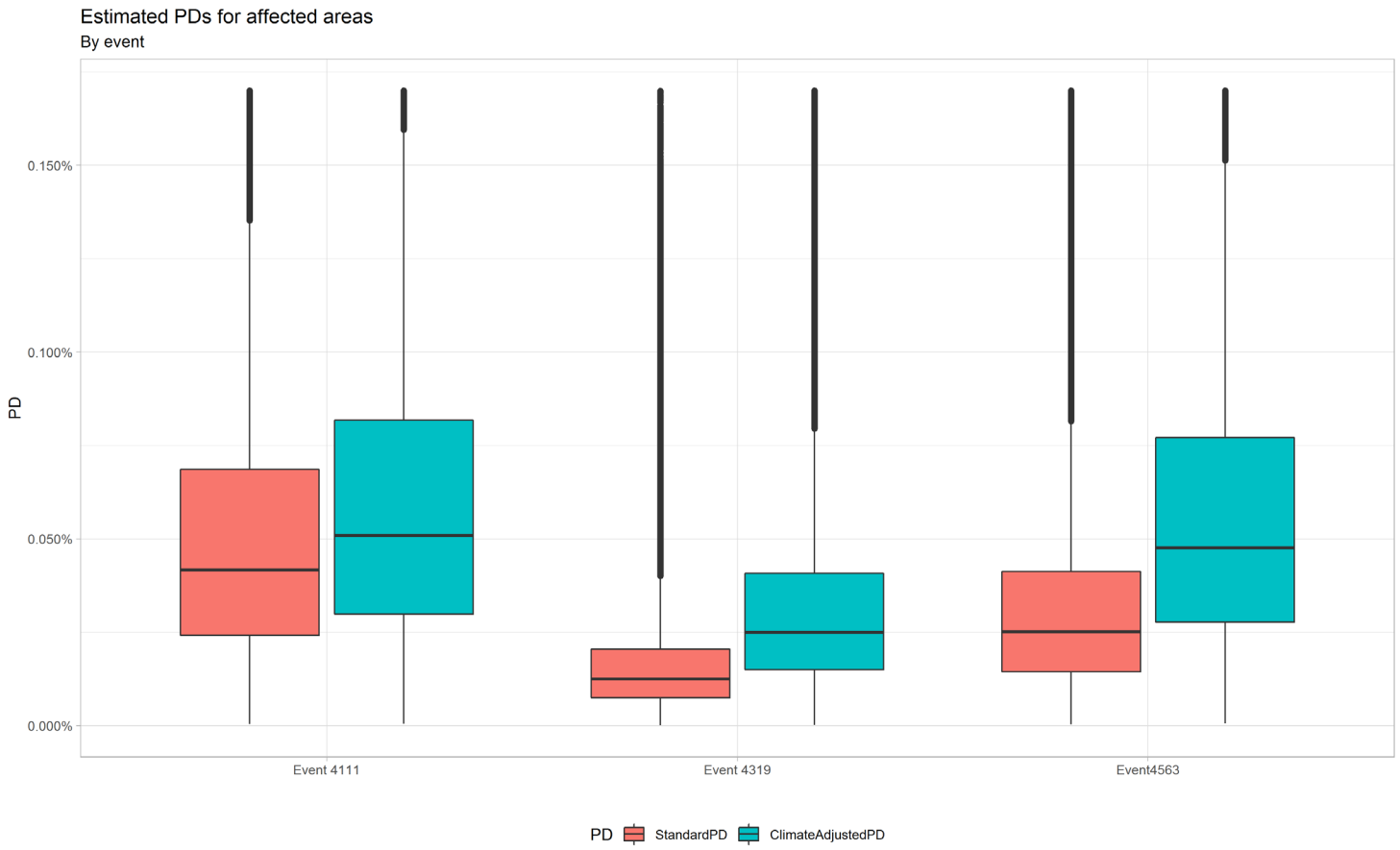


$\gamma = 0.697$



$\gamma = 0.664$

NUTS3 Estimated PD range



NUTS3 affected by Event 4111:

PD	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Standard	0.0004%	0.026%	0.046%	0.073%	0.081%	8.068%
Climate	0.0005%	0.033%	0.058%	0.093%	0.102%	10.022%

NUTS3 affected by Event 4319:

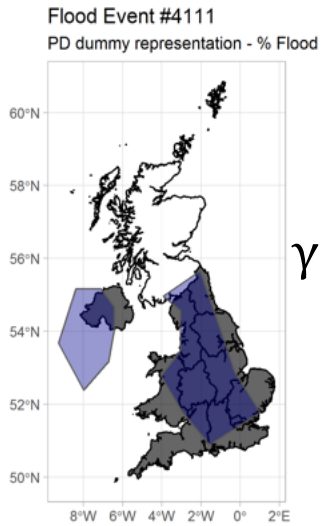
PD	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Standard	0.0001%	0.0075%	0.0125%	0.0164%	0.0205%	0.6301%
Climate	0.0002%	0.0150%	0.0252%	0.0329%	0.0412%	1.2572%

NUTS3 affected by Event 4563:

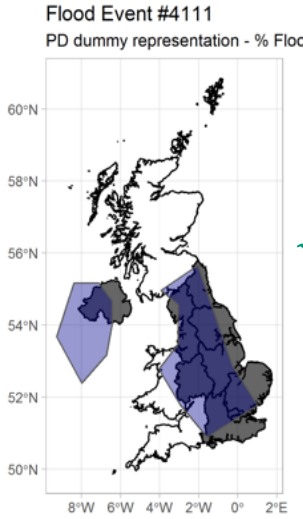
PD	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Standard	0.0003%	0.0145%	0.0253%	0.0314%	0.0414%	1.7183%
Climate	0.0006%	0.0281%	0.0491%	0.0610%	0.0805%	3.2863%

Areas of significant flood events – NUTS1

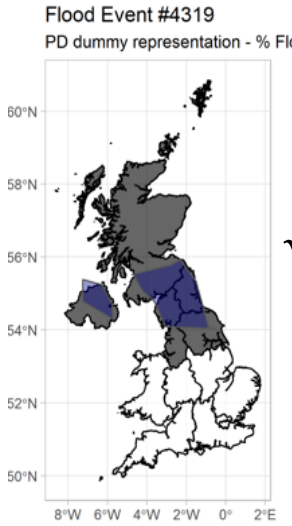
$$\ln\left(\frac{DR}{1-DR}\right) = \ln\left(\frac{\widehat{DR}}{1-\widehat{DR}}\right) + \gamma Event + \mu$$



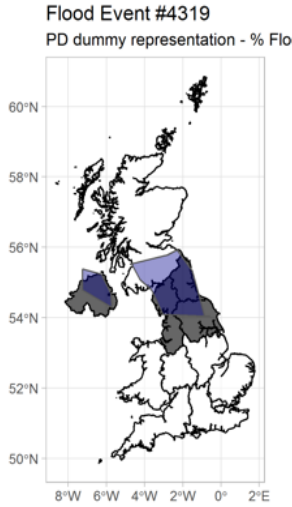
$\gamma = 0.306$



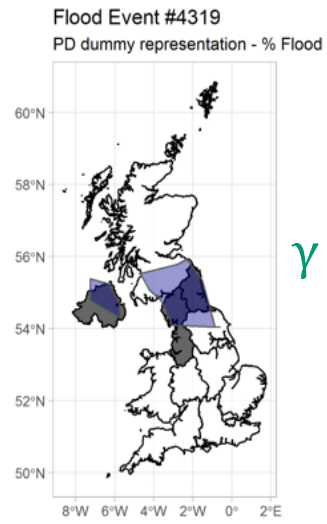
$\gamma = 0.245$



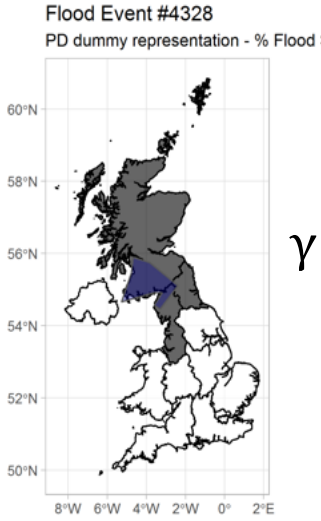
$\gamma = 0.282$



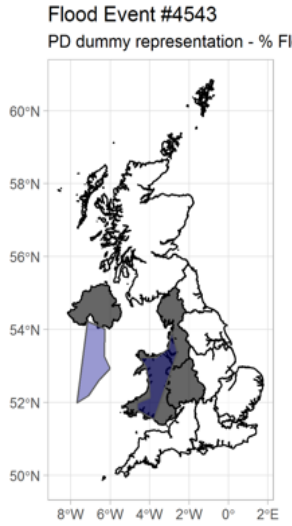
$\gamma = 0.412$



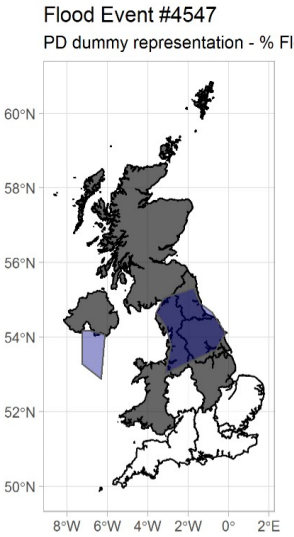
$\gamma = 0.427$



$\gamma = 0.365$

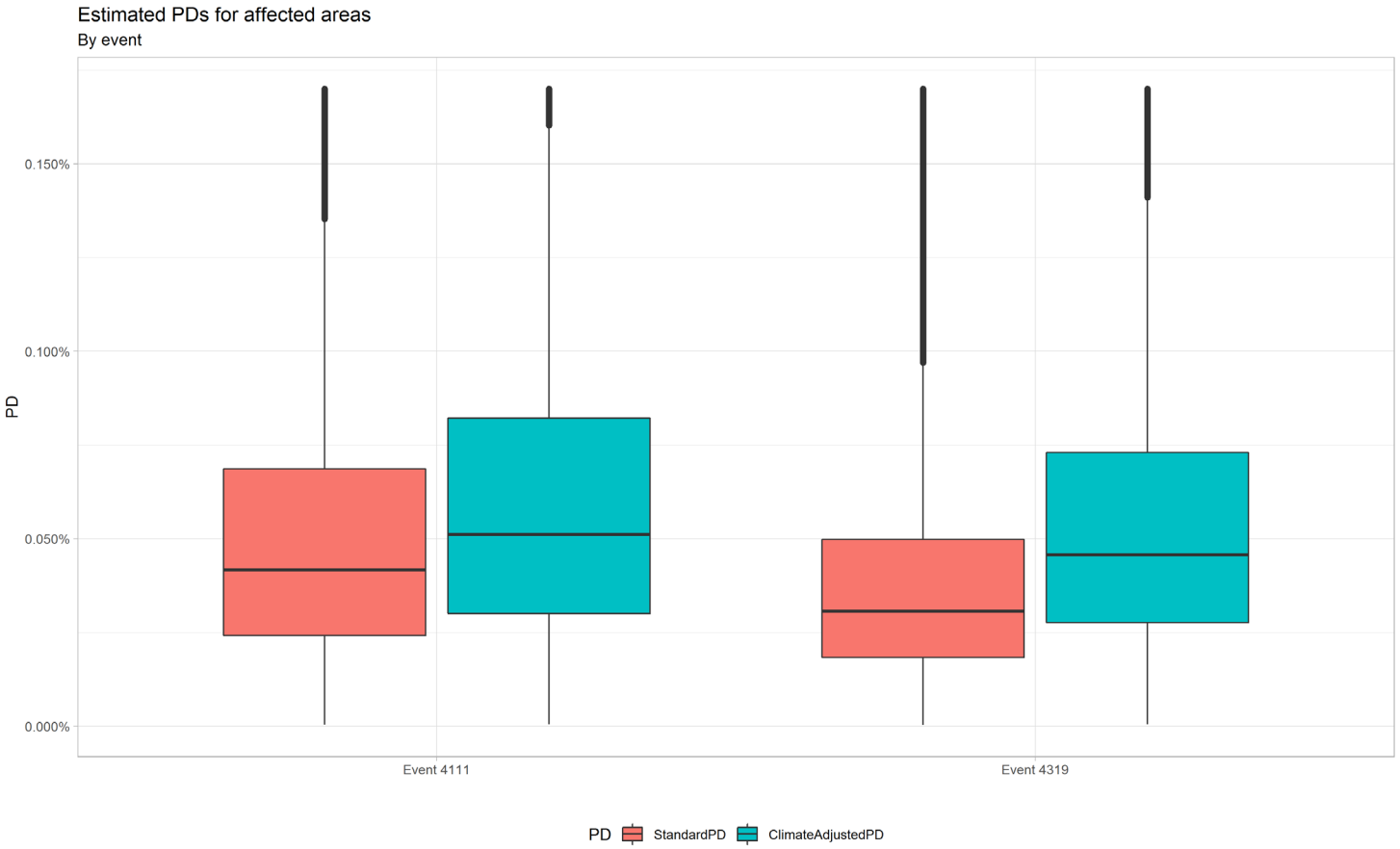


$\gamma = 0.249$



$\gamma = 0.249$

NUTS1 Estimated PD range



NUTS3 affected by Event 4111:

PD	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Standard	0.0004%	0.026%	0.046%	0.073%	0.081%	8.068%
Climate	0.0005%	0.033%	0.058%	0.093%	0.103%	10.085%

NUTS3 affected by Event 4319:

PD	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Standard	0.0001%	0.0075%	0.0125%	0.0164%	0.0205%	0.6301%
Climate	0.0005%	0.028%	0.048%	0.062%	0.078%	2.477%

4

Constructing score-adjusted climate change scenarios and climate-adjusted credit risk metrics

Polling Question

4. For a particular region – say, Greater London – what do you think is the largest absolute difference between the smallest and largest decline in HPI?

A. Less or equal 10%

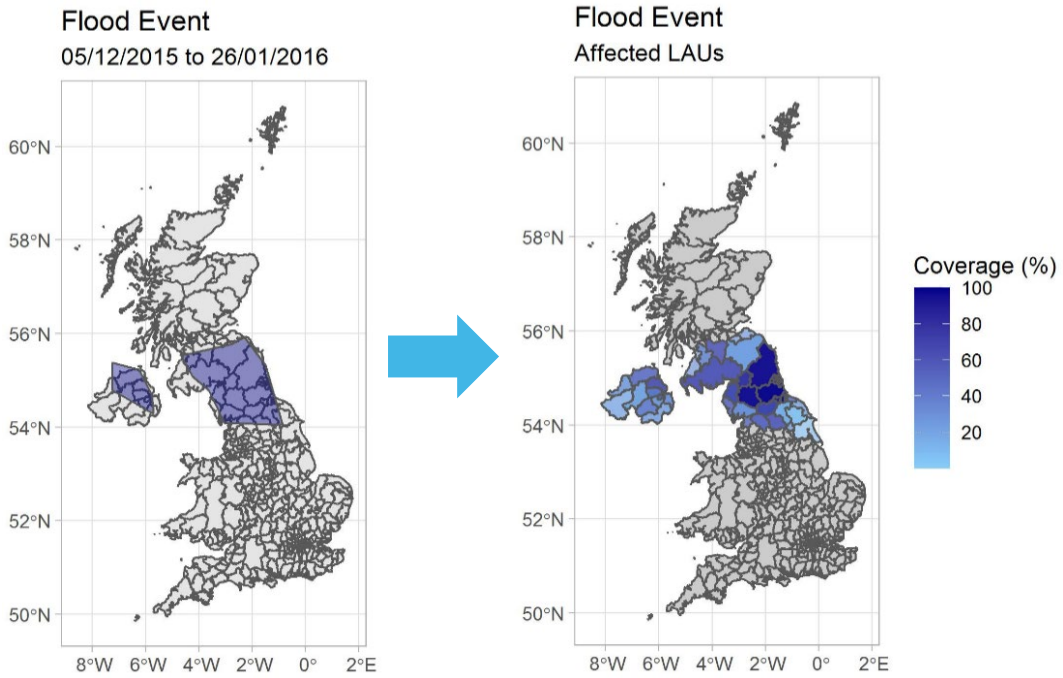
B. Greater than 10% but less or equal 20%

C. Greater than 20%

Linking Severity of Climate Events to Credit Risk

Impact of flooding in HPI

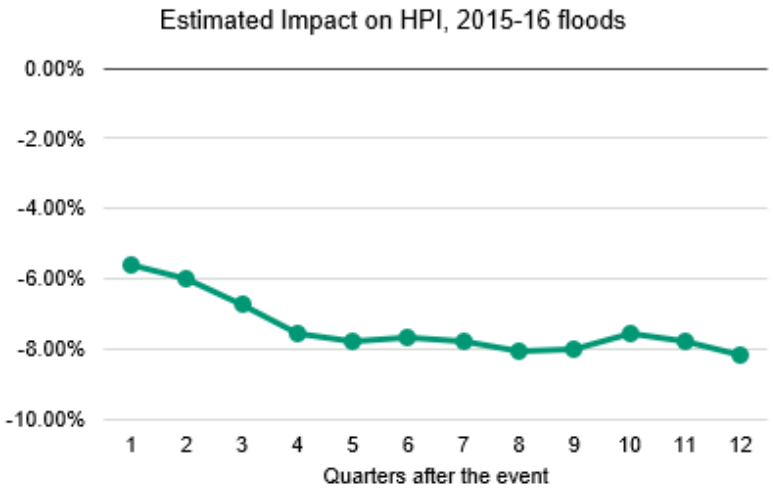
1. Analyse 70+ flooding events in the UK.
2. Classify the events based on severity.
3. Analyse the impact on HPI after the event is observed by severity buckets.



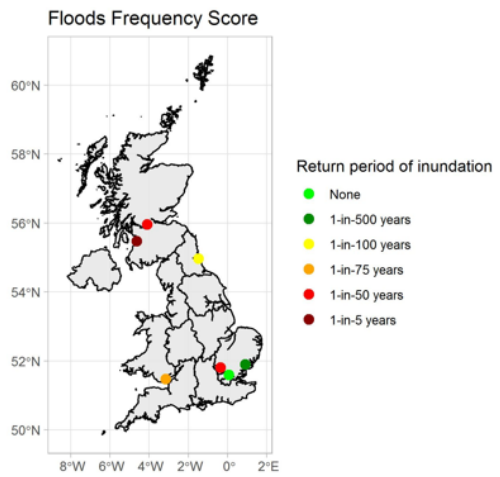
Fixed effect model

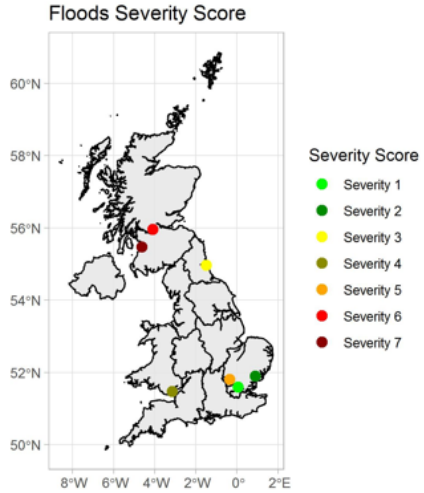
$$y_{it} = \alpha + \lambda_t + c_i + \tau_t D_{it} + \mu_{it}$$

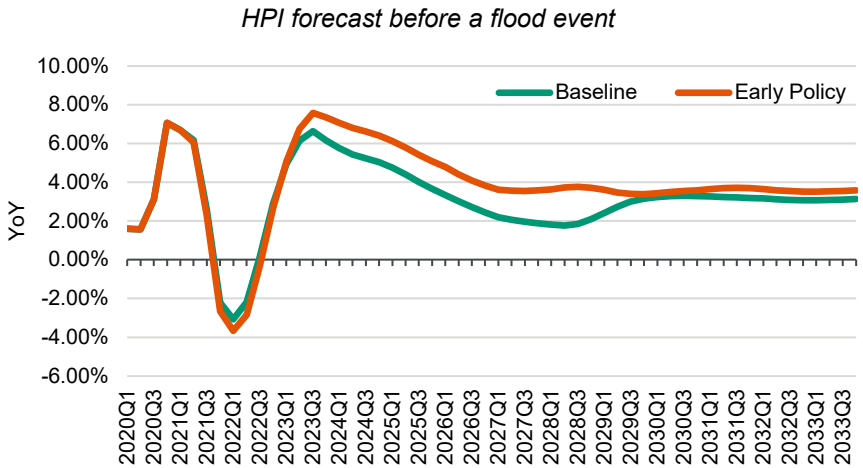
where
y_{it}: HPI for LAU *i* at time *t*,
λ_t: Time effect (year−quarter dummy),
c_i: Region fixed effect,
τ_t: Time-varying flood event effect,
D_{it}: flooded LAU (dummy)



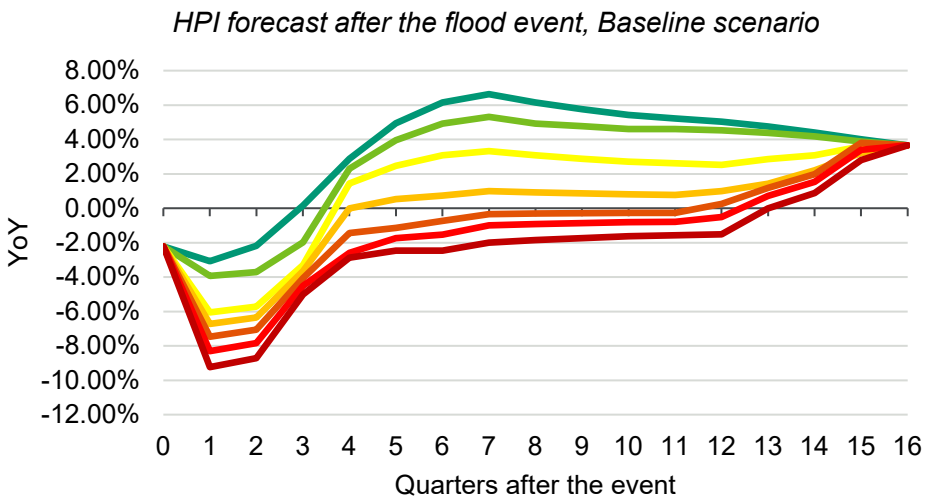
Impact of Flooding in Location-specific HPI

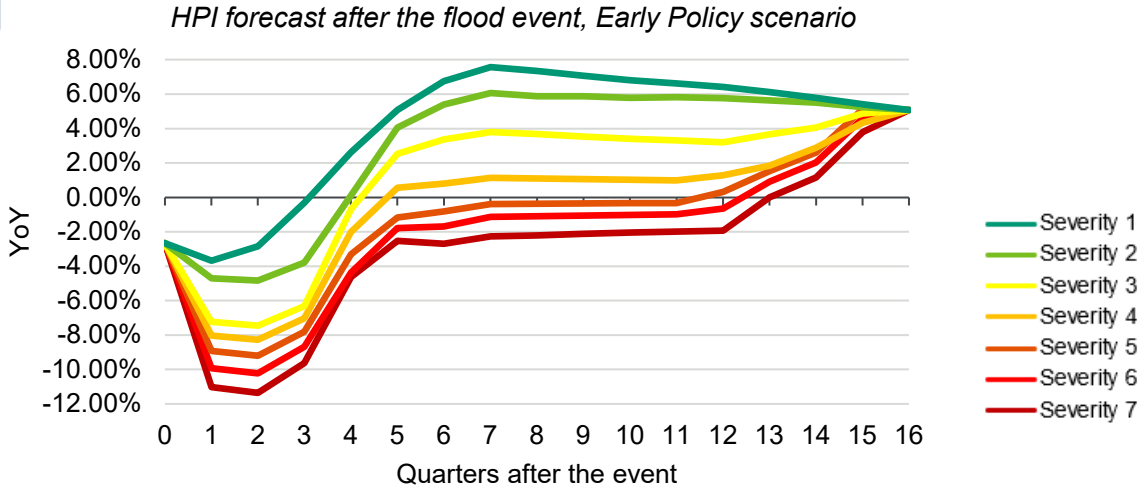






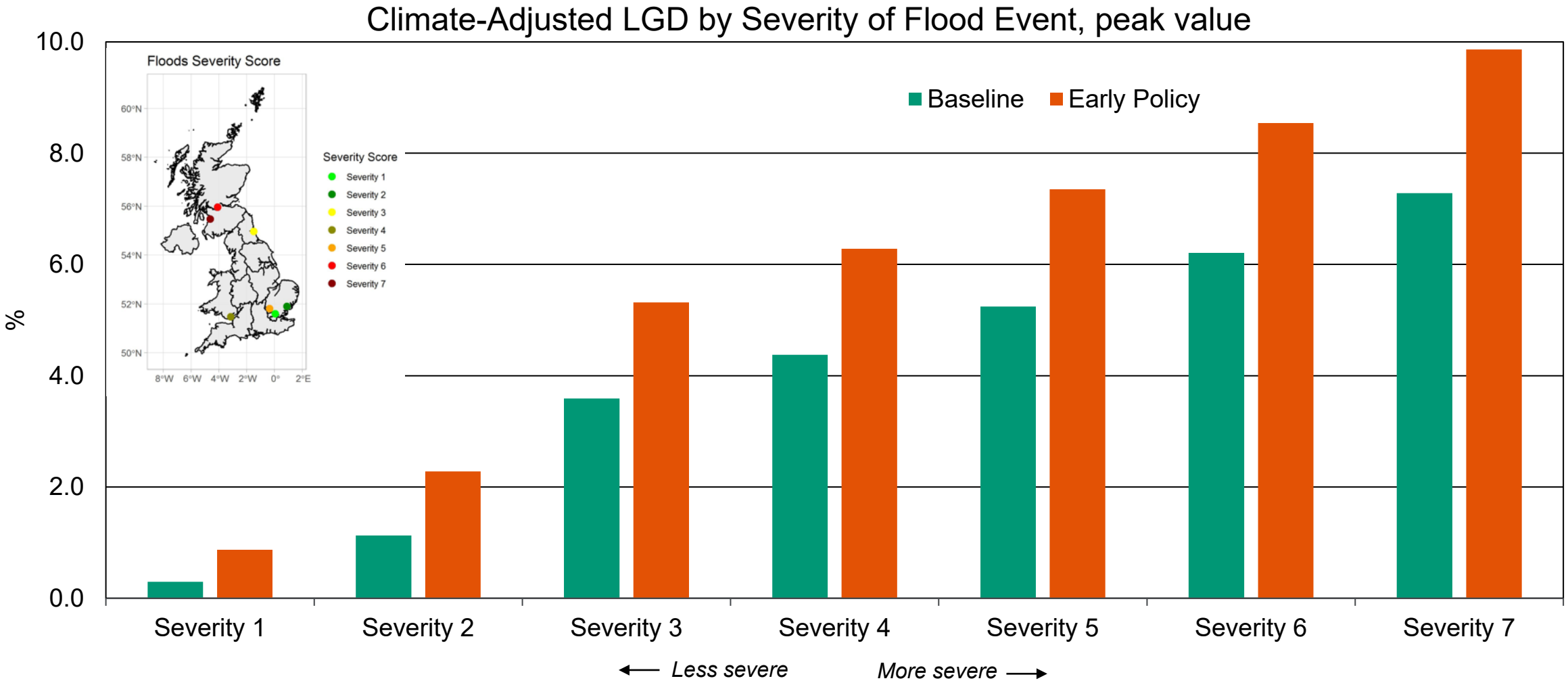
If a flood event is predicted to occur in 2021Q4





Impact of Flooding Events in LGD

Location-specific LGD

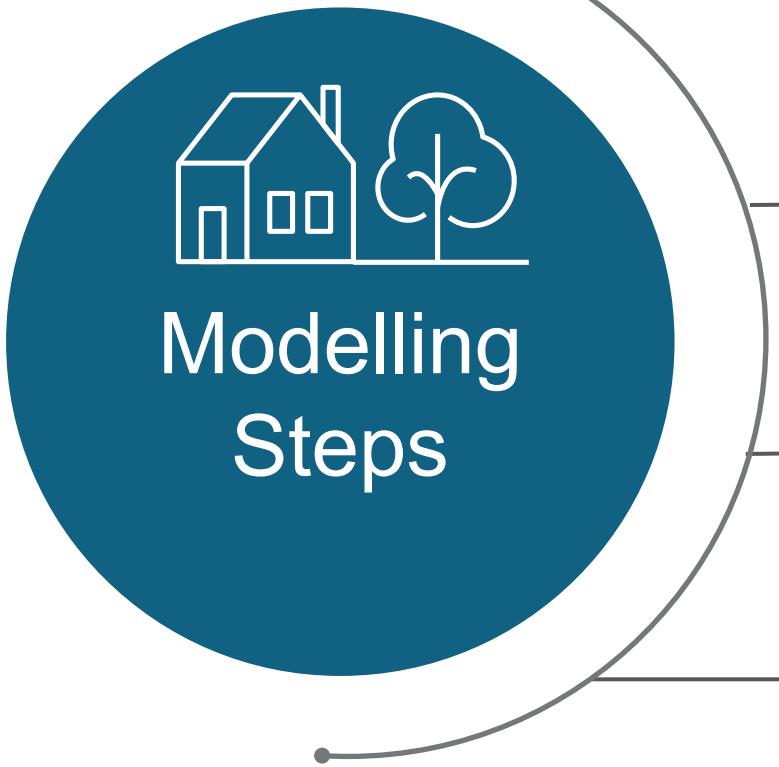


5

Climate Risk Adjustment

Location-Specific Climate Risk

Modelling Methodology



Climate Risk Scores

Obtain climate risk scores at the facility level. Access to six climate event risk scores based on the geographic location provided.

Climate Scenarios

Build country-specific climate scenarios (e.g., NGFS Current Policy, NGFS Early Policy, NGFS Late Policy).

Score-Adjusted Scenario

Compute climate event risk adjustments to the economy based on the climate risk scores and location such that riskier areas face more severe scenarios.

Climate-Adjusted Credit Risk Metrics

Forecast credit risk metrics (PDs, LGDs, EADs) based on score-adjusted climate scenarios.

Q&A

Additional questions? Email us at help@economy.com

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