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May 25, 2023

Data-Driven Climate Risk Assessments for Financial Regulation

Dr. Ed Kearns, First Street Foundation

First Street Foundation (FSF) is a 501(c)(3) nonprofit formed to make climate risk information accessible and useful to individuals, businesses, and governments.

We recognize an urgent need for consistent, property-level, publicly-available climate risk information for the entire United States for Financial Regulation, Insurance, Corporate Disclosure, and Infrastructure applications. Transparency is a major consideration for data use by regulators and regulated industries.

Since June 2020, we have used Open Science to create and publicly distribute property-specific estimates of risk from flood, wildfire, hurricane winds, and heat for today and 30 years into the future. Air quality and Drought are up next for First Street in 2023.

US Federal Government is beginning a regulatory response to climate change risk.

Securities and Exchange Commission

In March 2022, proposed a rule that is intended to enhance and standardize the climate-related disclosures provided by public companies. Under the proposed rule, a registrant would be required to provide disclosures in its registration statements and annual reports.

This includes climate-related impacts on financial estimates and assumptions to be presented in a footnote to the audited financial statements. Disclosures subject to managements internal control over financial report (ICFR) and external audit. A decision is coming this April.

Office of the Comptroller of the Currency

In December of 2021, they published draft principles for banks on managing climate related risks for banks with more than $100 billion in total assets. This included 5 questions every bank board should ask.

In January of 2022 they released a new management survey that has 17 questions including maturity of climate risk management frameworks and impact on credit and pricing.

Federal Reserve Board

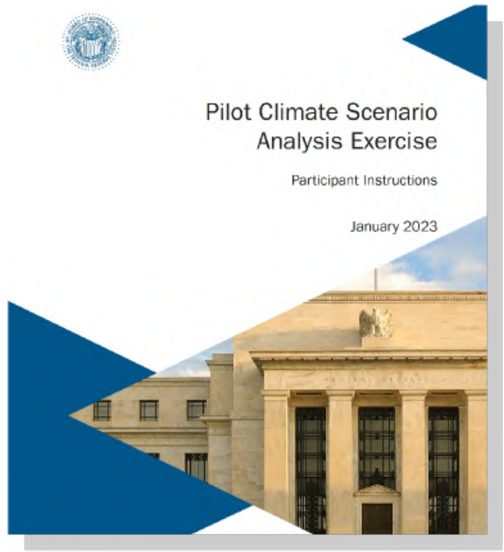
December of 2020 they joined the network of central banks and supervisors for greening the financial system (NGFS).

In February of 2021 they started meetings and letters with the top financial institutions talking about risk management, scenarios analysis, innovation and experimenting with approaches. Then in September of 2022 the board announced that six of the nations largest banks will participate in a pilot to measure and manage climate-related financial risk. Finally on January 19th, 2023 they issued guidance for the test cases for the six banks trial disclosure.

Federal Deposit Insurance Corporation

March of 2022, they published draft principles for banks on managing climate related risks with more than 100 billion in assets. Their draft principles are very similar to the OCC proposals which were issued in December of 2021.

In March of 2022 they also requested public comment on their draft principles.



FRB to the 6 largest US Banks:

Consider 2 Shock Scenarios for Physical Climate Risk

1. Major Hurricane(s) landfall in the NE US (Flood and Wind)
2. Event of the Banks' choosing, in a US region (Flood? Fire? Wind?)

And report back by July 31, 2023 on each loans' risk , probability of default, and loss given default projections.

Table 4. Summary of physical risk shocks

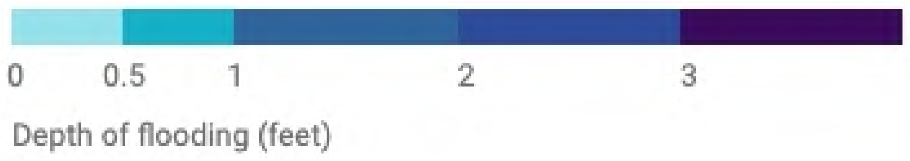
Iteration	Severity			Impact		Mitigant
	Climate pathway	Return period loss	Year of shock	Hazard	Geography	Property insurance
Common shock						
1	SSP2-4.5/RCP 4.5	100-year	2050	Severe hurricane(s)	Northeast NCA region	Existing coverage
2	SSP5-8.5/RCP 8.5	200-year	2050	Severe hurricane(s)	Northeast NCA region	Existing coverage
3	SSP5-8.5/RCP 8.5	200-year	2050	Severe hurricane(s)	Northeast NCA region	No coverage
Idiosyncratic shock						
4	SSP2-4.5/RCP 4.5	100-year	2050	Participant chosen	Participant chosen NCA Region	Existing coverage
5	SSP5-8.5/RCP 8.5	200-year	2050	Participant chosen	Participant chosen NCA Region	Existing coverage
6	SSP5-8.5/RCP 8.5	200-year	2050	Participant chosen	Participant chosen NCA Region	No coverage

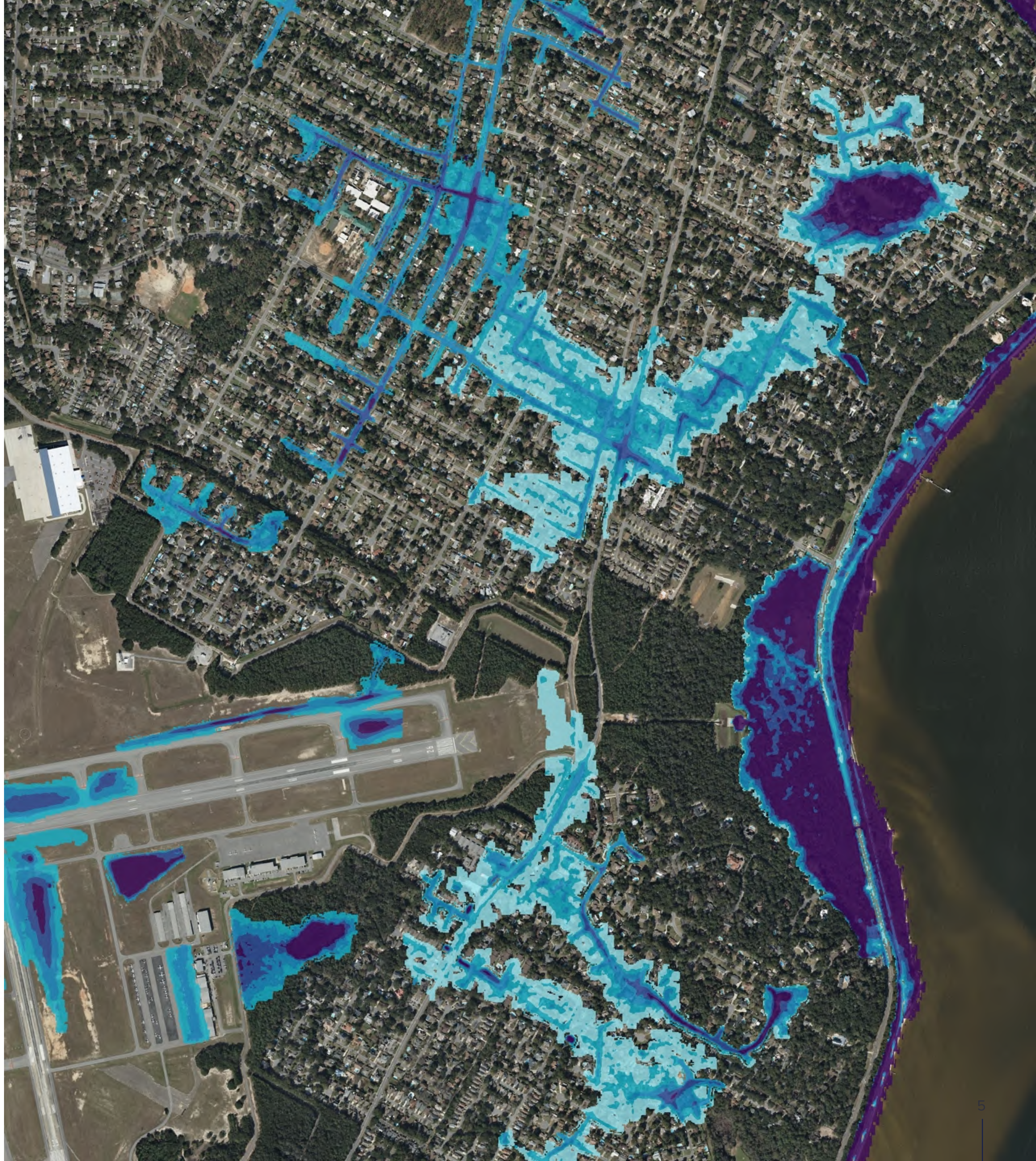
"...as part of a regulated financial institution, [Private Bank] needs to undergo a rigorous validation process for any model that we bring into the bank. As part of this, we need to document the model according to the requirements of the Federal Reserve Board, which requires us to write up the methodology to a sufficient standard that the model could be reproduced from the documentation." - a Major Bank, May 2023

What does a flood risk map look like? FSF compound flood hazard layers at a 3 meter resolution (Pensacola, FL)

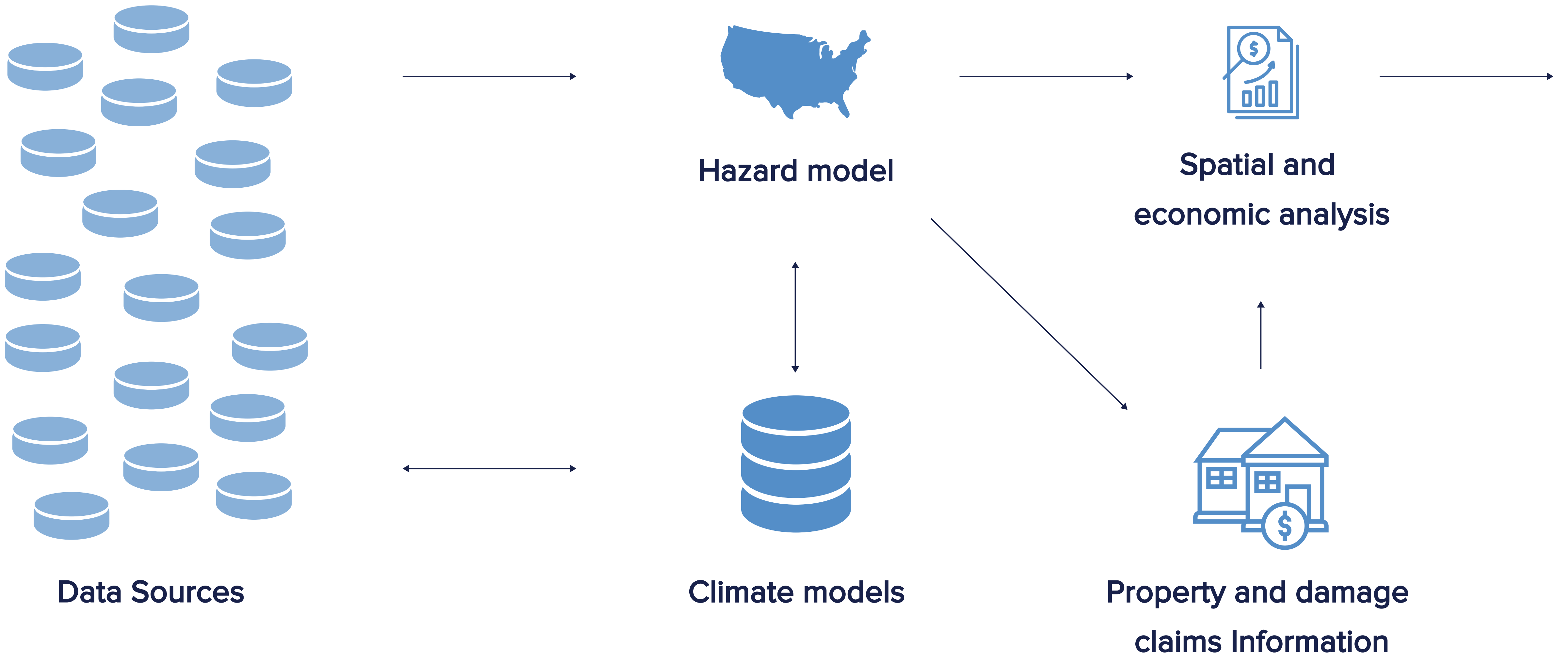
FSF's flood model accounts for the topography of an area (elevation), where creeks or rivers channel water, heavy rainfall, surge and sea level rise — and the expected capacity of the flood protection systems to stop flooding. It was then run for different likelihoods (probabilities or "return periods") to know where we would expect flood water under each scenario and the associated depth of that water for every 3 meter by 3 meter cell across the landscape.

3m resolution, Pensacola, FL





FSF distills data into property-specific climate risk statistics, using **deterministic models** of each peril. This is very computationally intensive, but necessary for adequate resolution and fidelity at the property level (3m-10m horizontal resolution).

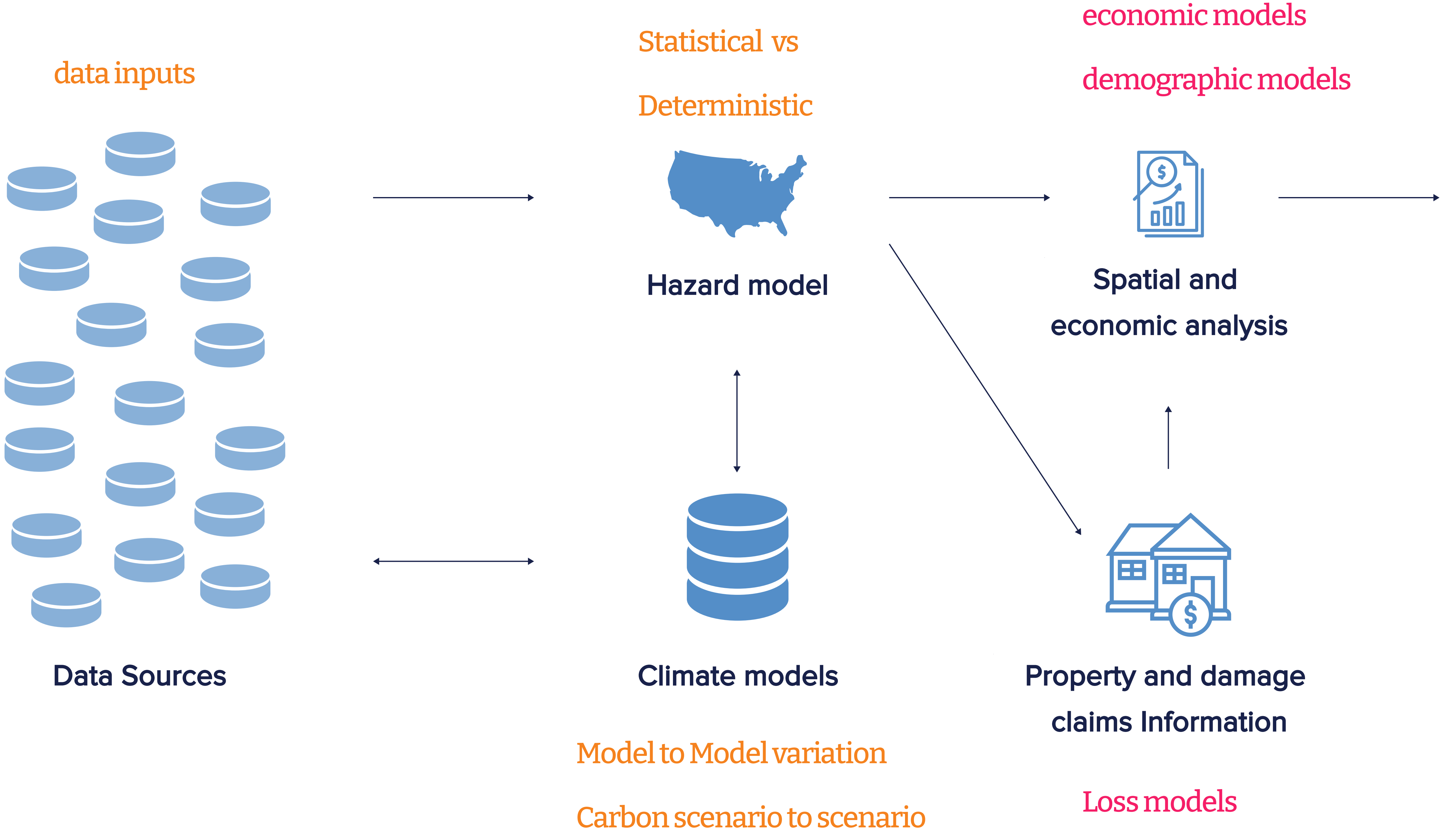


RISK FACTOR

Every property is assigned:

1. Risk Score 1-10
2. Expected Losses as $

Uncertainties matter - where do they come from? How big are they? What kind of uncertainties are introduced?



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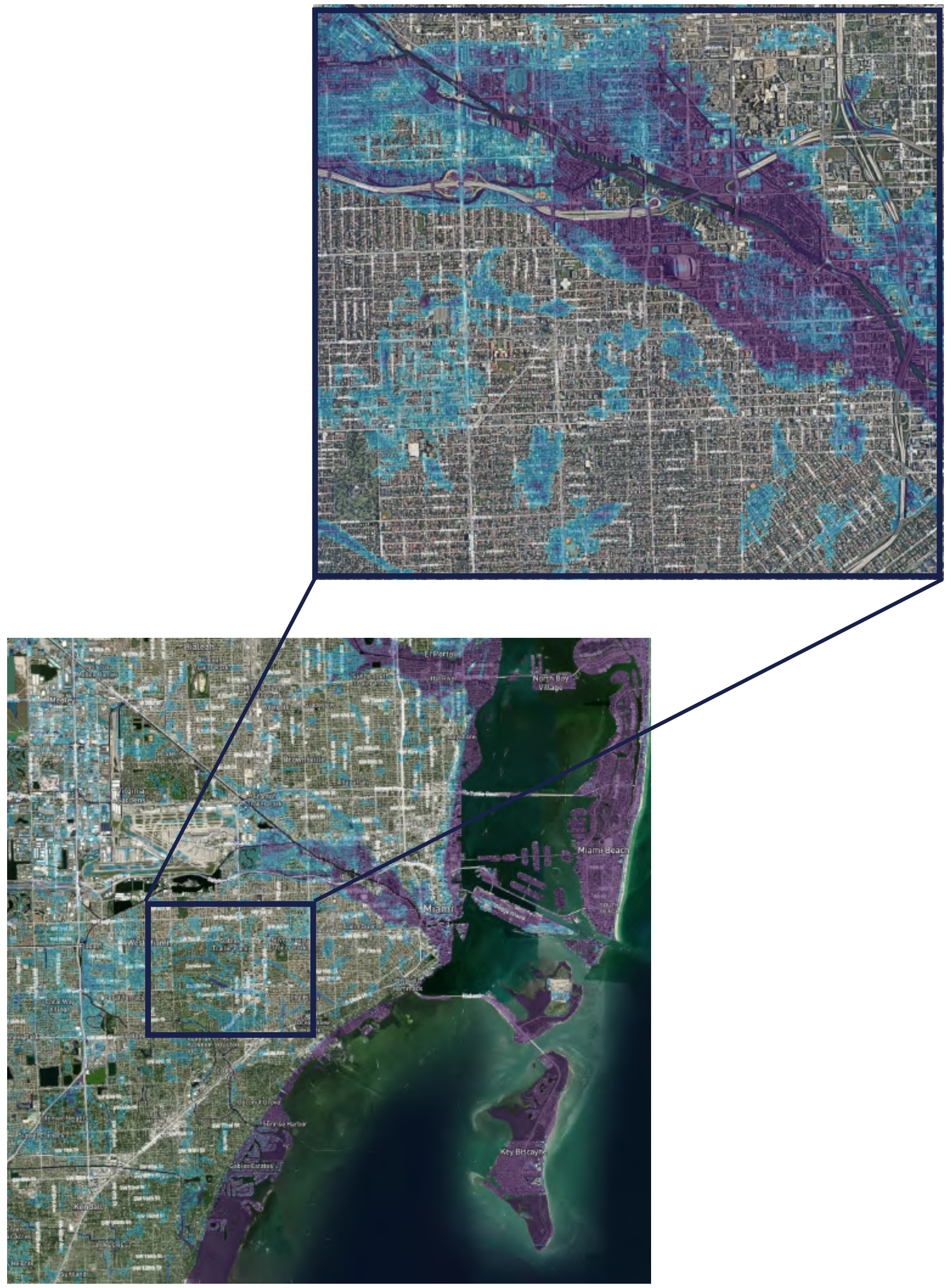
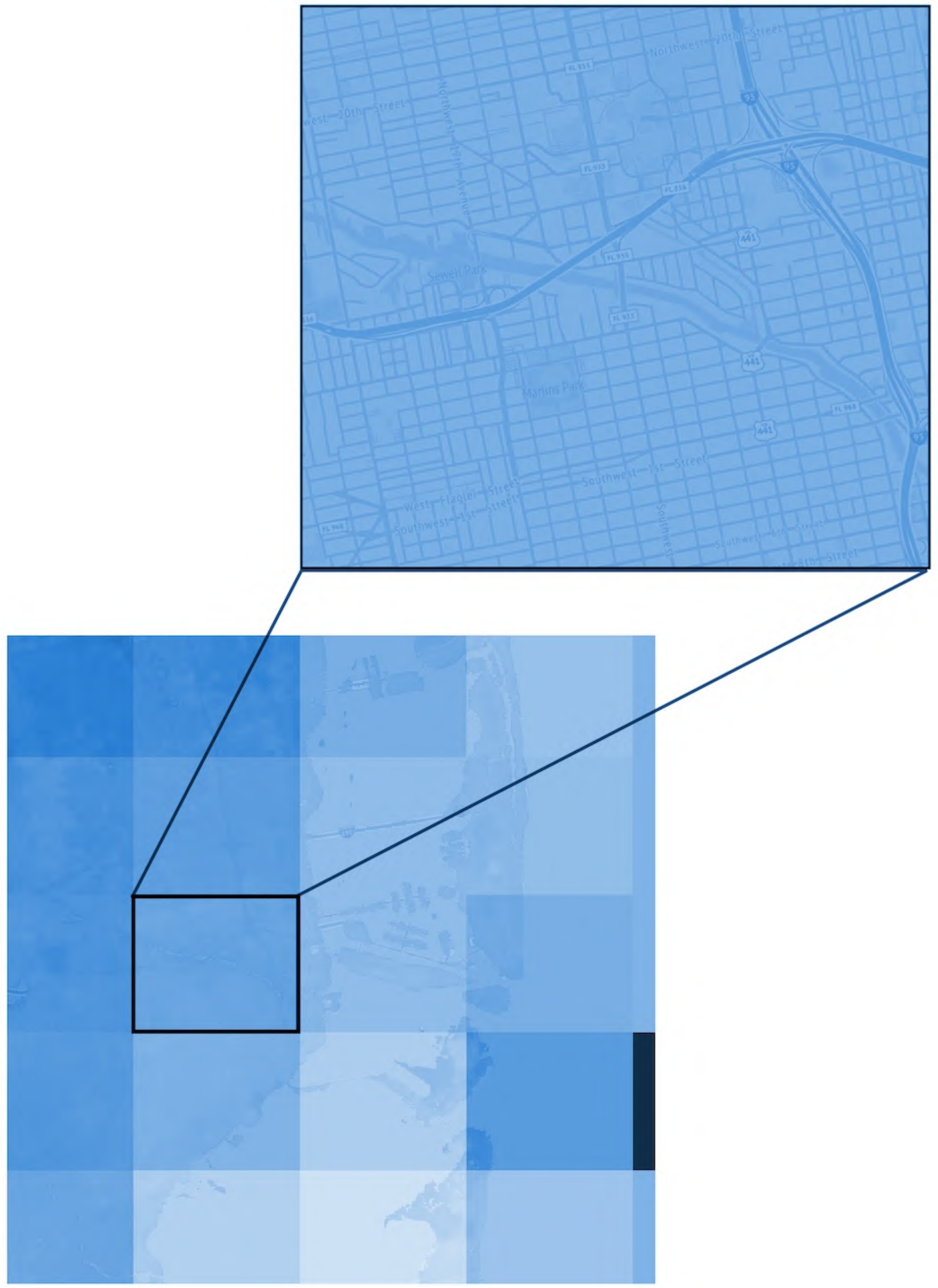
Climate Model Downscaling

- Climate models use a coarse (~100 km) resolution for the entire globe to enable computation.
- Can go from coarse to fine scale by "downscaling" either statistically or dynamically

- Risky: Leaping from a climate model to some conclusion about local risk may be too big a leap - depends on information used to downscale.
- Safer: Can use downscaled models as inputs to drive either deterministic or statistical models to get to high resolution (30m or better)

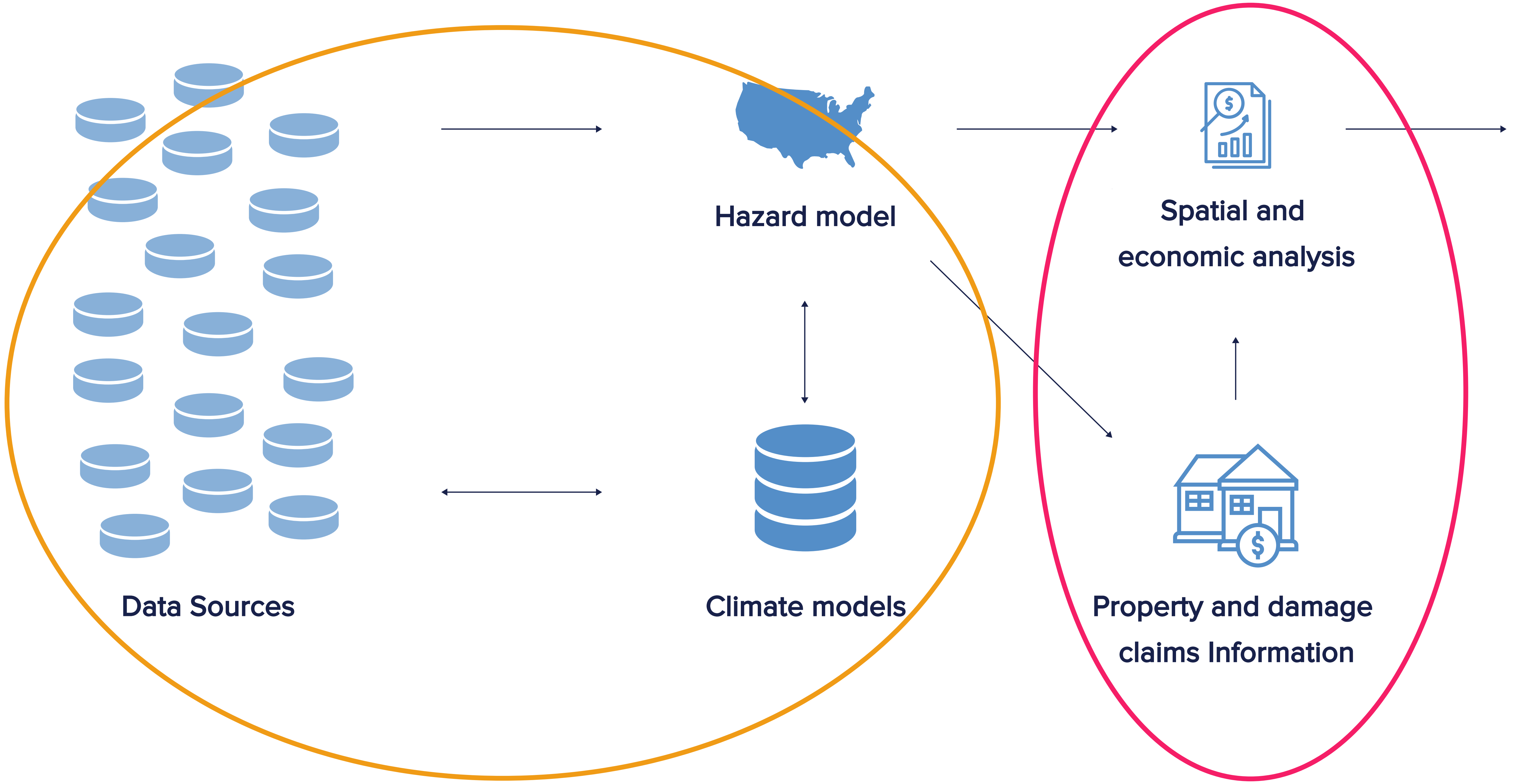


3 meter resolution FSF hydraulic flood model



2 km downscaled precipitation climate model

Physical Risk Data + Economic Data = Useful Climate Risk Information



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Every property is assigned:

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We use transparent methods based on U.S. Government open data - to enable reproducibility and trust.

First Street uses Open Science methodologies, publishing all our methods and results.

RISK FACTOR

NOAA: Wx Reanalysis, Precipitation Frequency Data (Atlas 14), Tide Gauges, HURSAT hurricanes

USGS: LandSat, Stream Flows, National Elevation Database

USFS: LANDFIRE

USDA: NAIP

USACE: National Levee Database

Data inputs

LISFLOOD
ELMFIRE
Synthetic hurricanes

Hazard model

IPCC CMIP5
NASA-NEX
MACAv2
IPCC CMIP6
- SSP245
- SSP585

Climate models

Enviro Data are Key to Accurate Hazards Estimates

Spatial and economic analysis

Compute AALs
1:2 to 1:500 Return Periods

Arup: Fragility curves

FEMA: NRI, Aggregated claims data, Flood Zones

USFS: Wildfirerisk.org

USACE: Depth-Damage Curves, National Structure Inventory

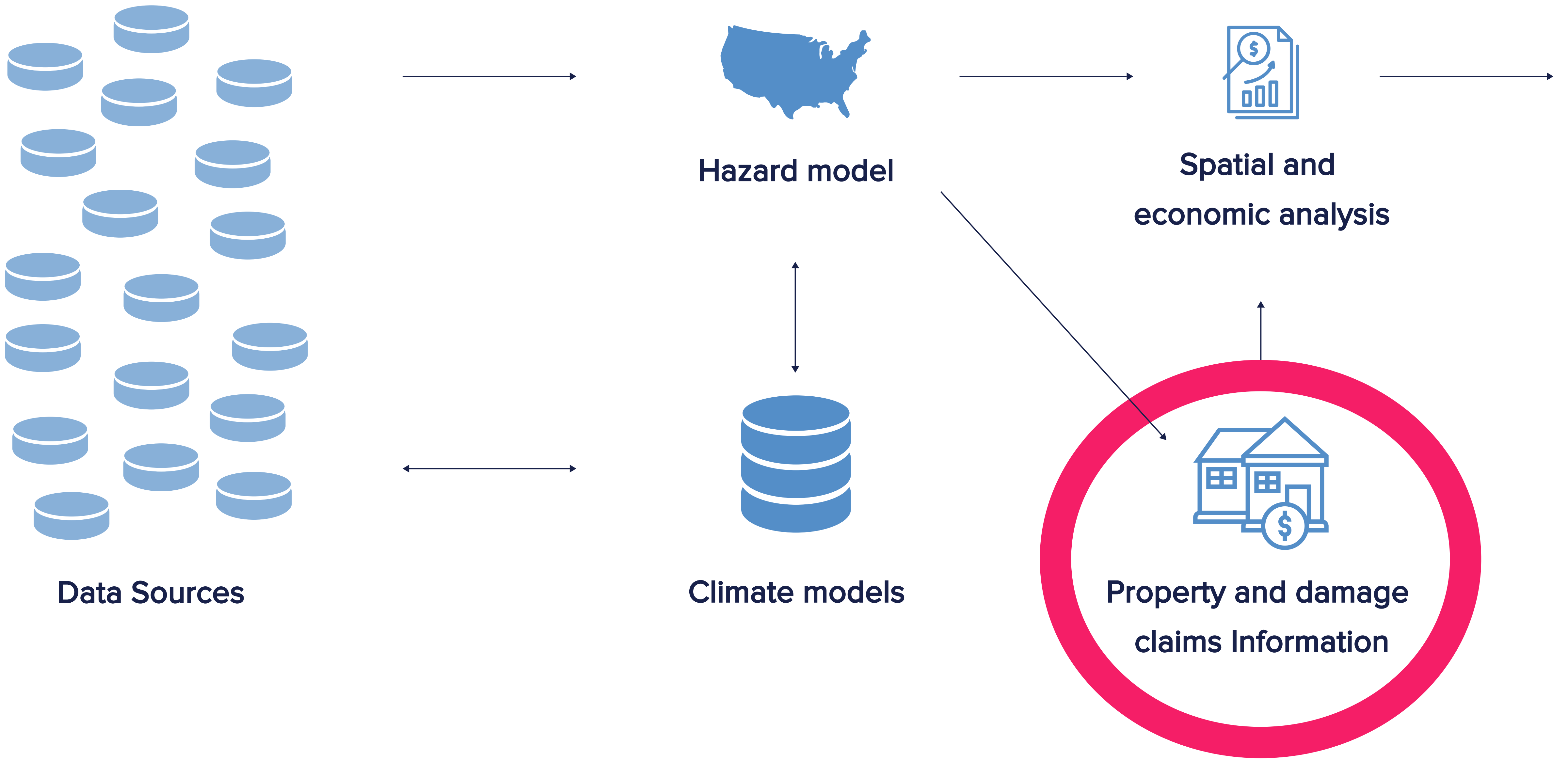
Property and damage claims information

Data simplified as understandable information:

1. Risk Score 1-10
2. Expected Losses $

Claims Data are Key to Accurate Loss Estimates

Estimates of losses from climate change - needed by financial institutions



RISK FACTOR

Every property is assigned:

1. Risk Score 1-10
2. Expected Losses as $

FSF models calculate risk and likely losses for each individual property for 2023 and 2053.

How physical climate hazards impact a structure depends on the specific vulnerability of the building. Using the First Street Foundation hazard models to understand the properties exposure matched with the building characteristics, we leverage fragility curves from the global engineering firm **Arup** to understand every buildings vulnerability and consequence.

- Flood
- Fire
- Heat
- Wind

Missile environment
Flying debris is more likely in denser urban areas.

Roof Type
A combustible roof type like wood shingles increases burn probability and wind damage likelihood

Defensible space
Combustible material within 50 ft increases burn probability

Construction material
Combustible exterior walls increase burn probability and exposure to wind damage

Number of stories
Taller buildings are exposed to higher wind speeds.

AC/Cooling
Based on the Sq Ft of the home, year built for age of AC, and temp, we derive KwH and cost by year

Direction of broad side of structure
Larger surface areas exposed to direct wind gusts cause more damage.

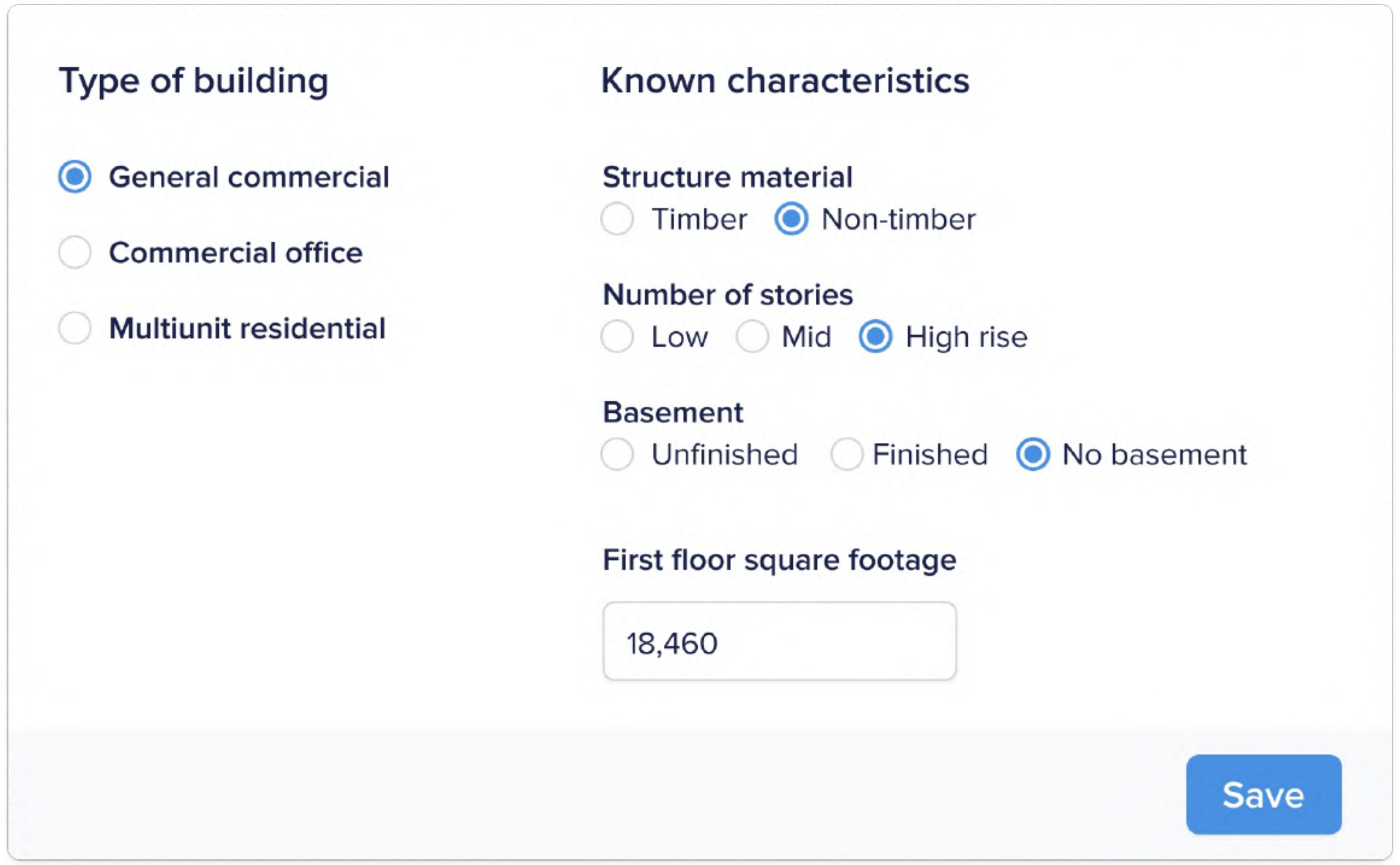
Basement
The presence of a basement and finish of the basement changes damage functions

Vent exposure
Vents in eaves increases burn probability from flying embers

First floor elevation
The height of the first finished floor determines the likelihood of severity of flood damage

We partnered with Arup to calculate economic damage for every commercial building

Leveraging our partnership with the engineering firm Arup, we use the known structure characteristics database to reverse engineer the building construction materials and identify the likely location of all critical components of the structure.



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Reverse engineered building plan with location of critical components

From there, we created loss curves for 30 specific building types based on known failure points and adjust cost by location.

ARUP was able to create component-specific fragility curves that calculate the damage to various building components baed on depth of water inside. These are leveraged to develop building level loss curves which include the high (90th percentile), mid (50th percentile), and low (10th percentile) loss estimates to demonstrate the range of potential outcomes.

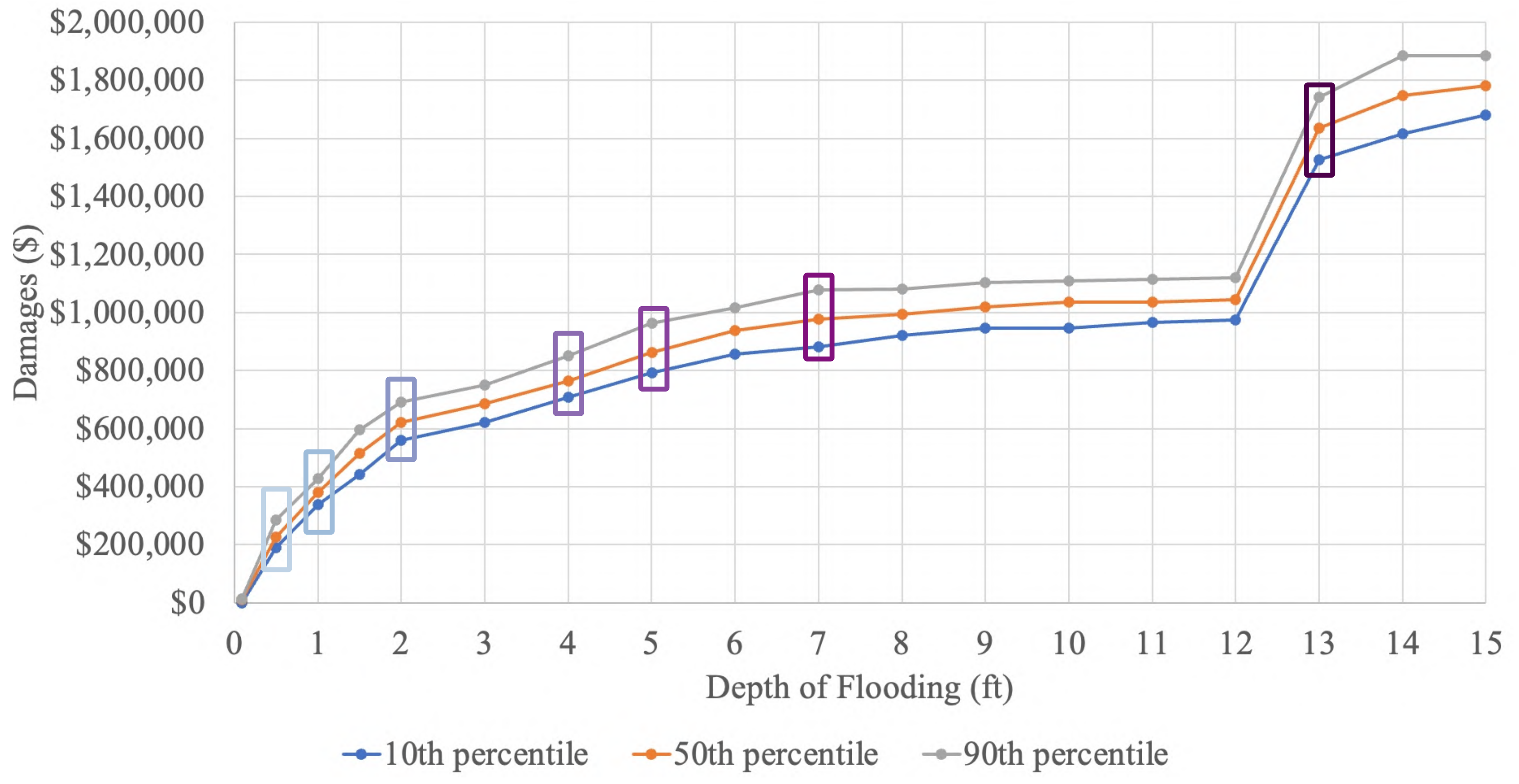
7 ft.
13 ft.
- ☐ Second floor compromised

5 ft.
4 ft.
- ☐ Elevator mechanics destroyed

2 ft.
1 ft.
- ☐ First floor windows destroyed

6 in.
- ☐ Washrooms and plumbing inoperable
- ☐ Elevators damaged
- ☐ First floor electrical outlets impacted
- ☐ First floor drywall and insulation damaged

An example of the depth-loss curve for high-rise non-timber commercial buildings without a basement in D.C.



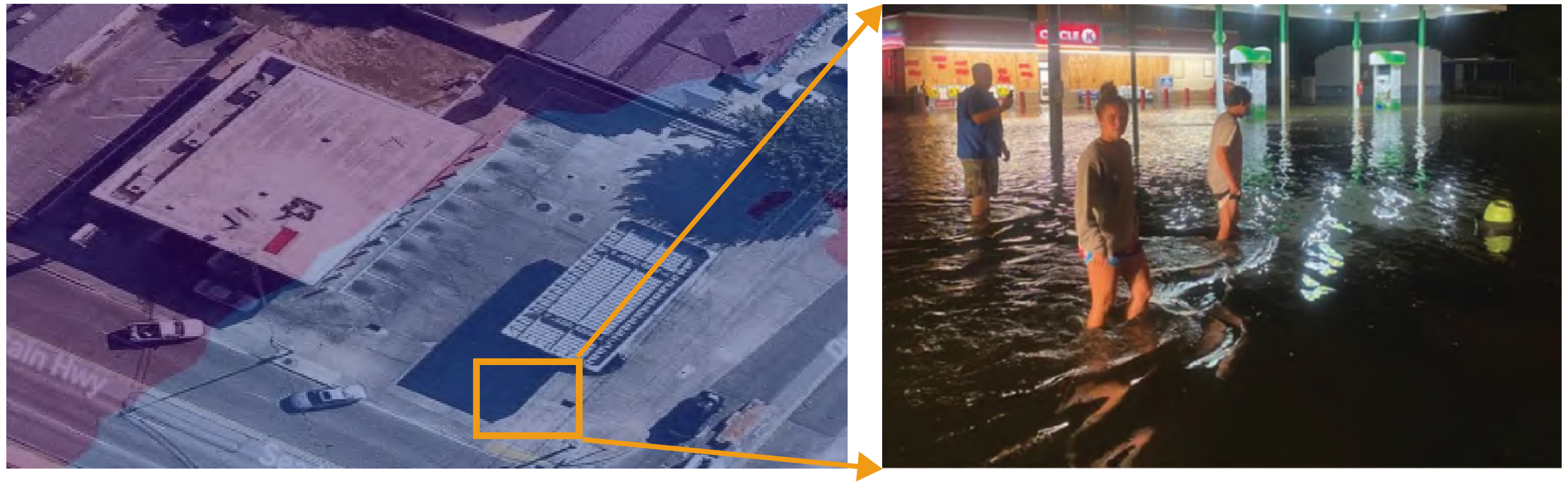
Calibration and Validation of Models using Actual Events

Compare current-year peril events against expectations

- group by probability ("return period" or likelihood to occur)
- measure the hazard exposure (extent and severity)
- **collect individual property loss information (can be difficult with privacy concerns)**
- use satellite data, on-ground observations, operational modeling

Aggregate these results over multiple events.

- collects scores for each event, over many events
- provide real-world metrics of uncertainty for near-term events
- use near-term metrics as proxy for future predictions' metrics



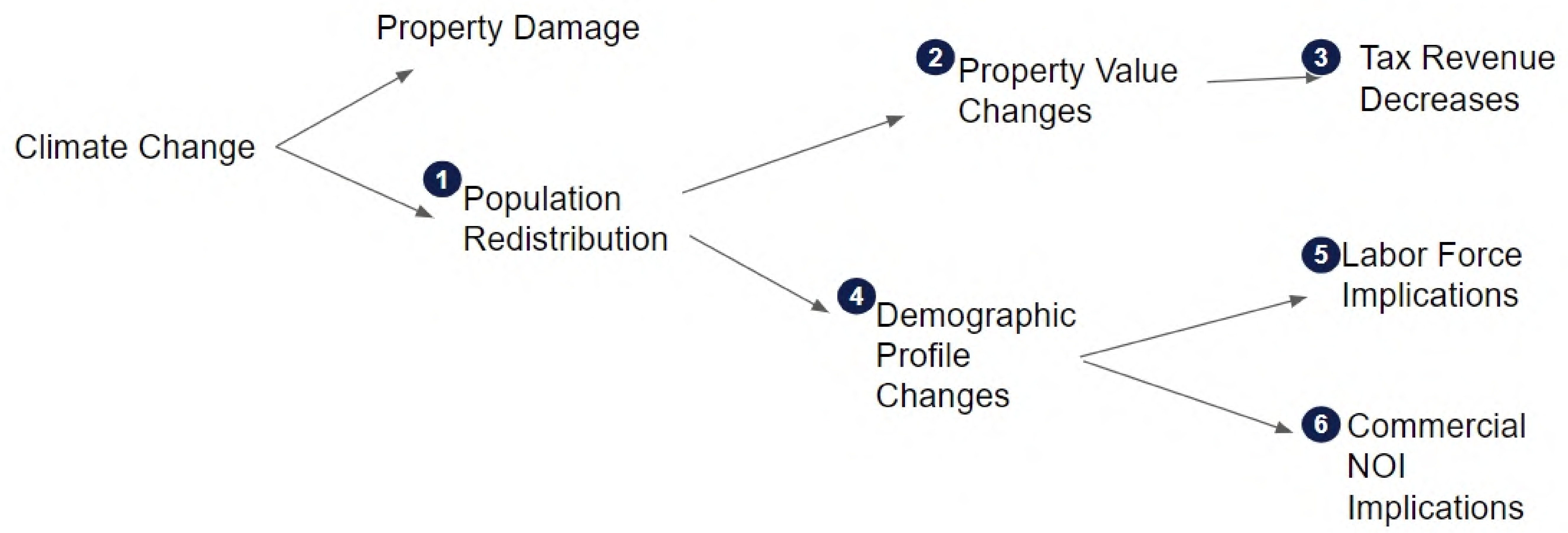
Cherry Grove Beach

Pensacola Florida

Ongoing Work: Connecting Downstream Derivative Implications to Climate Risk/Exposure

Following the completion of the Climate Migration workflow, FSF will be introducing those population change expectations into a series of derivative products that we are already working on:

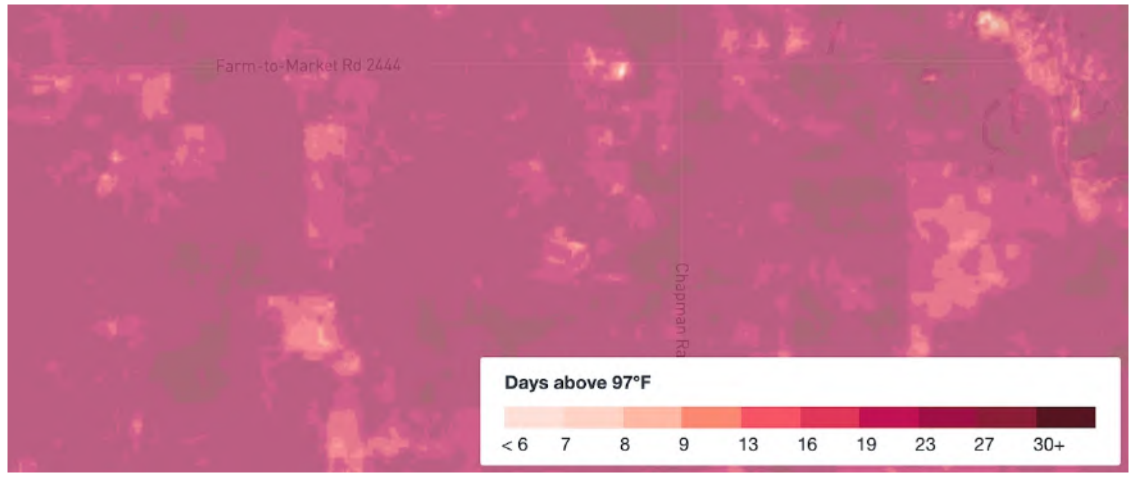
- Property Value Implications from Population Change
- Tax Revenue Projections Associated with Property Value Changes
- Future Projections on Demographic Composition Changes
- Labor Force Impacts
- Commercial Real Estate Implications from the changing Population Levels and Demographic Composition.

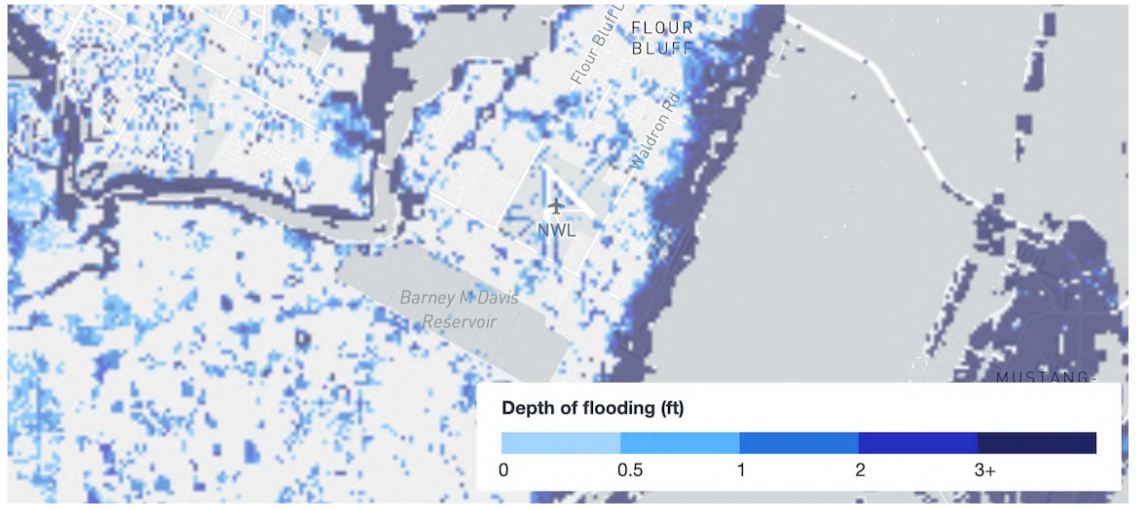


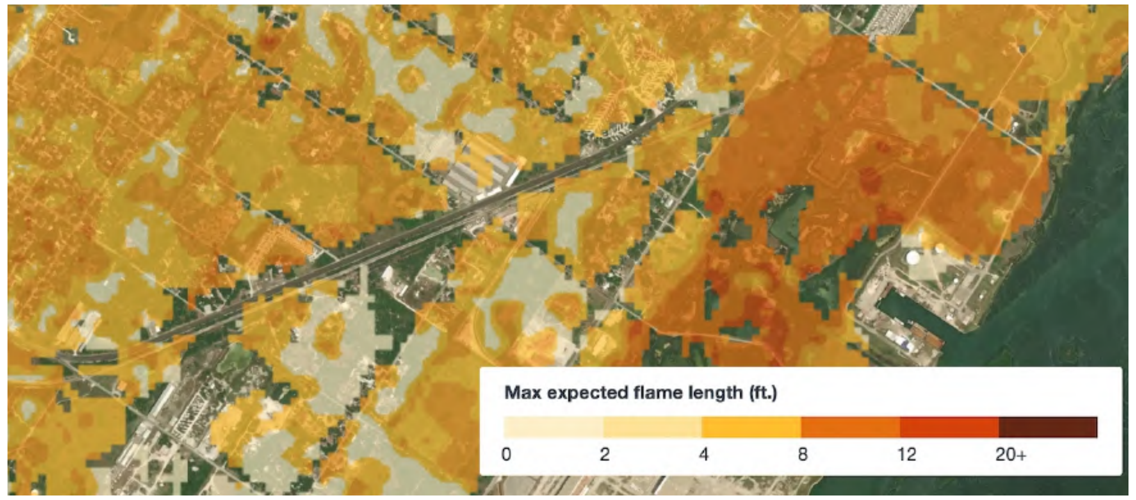
Going well….

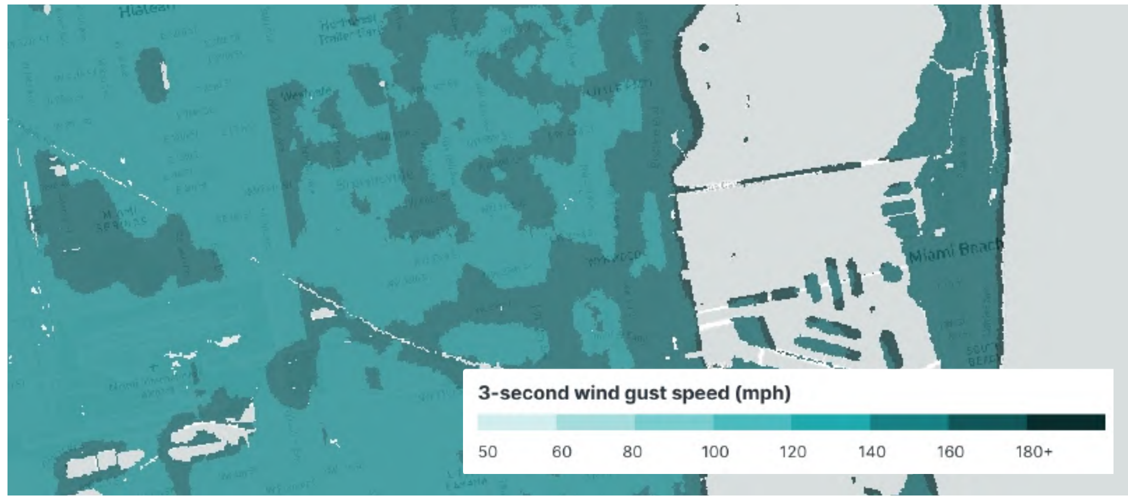
- **Environmental Data:** Federal Open Data are very valuable, existing access points are generally effective (cloud-based are best); sometimes have trouble getting newer results released quickly enough by agencies

- **Demographic data:** Federal open data from Census are valuable and available at the aggregate level (tract, block group, block)





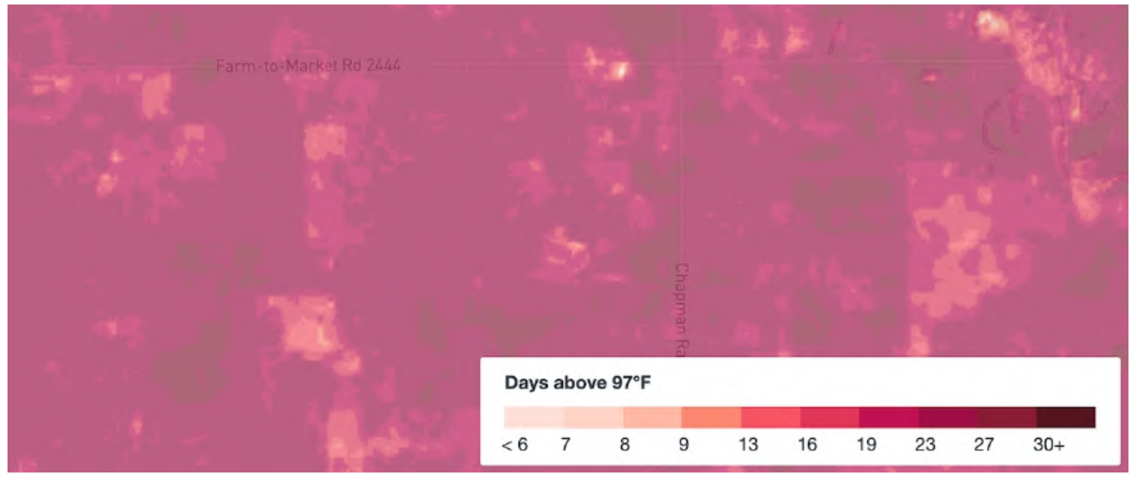


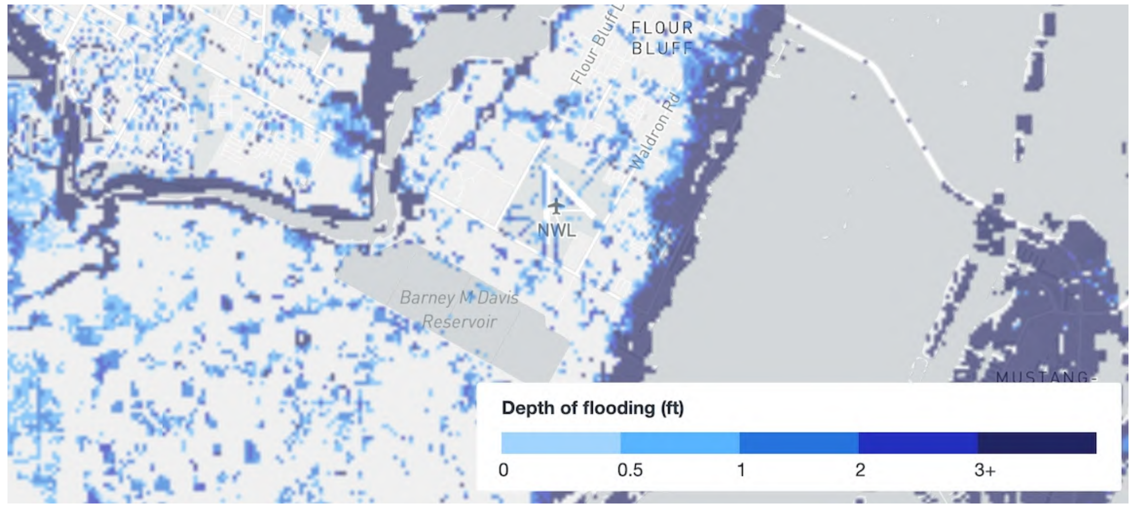


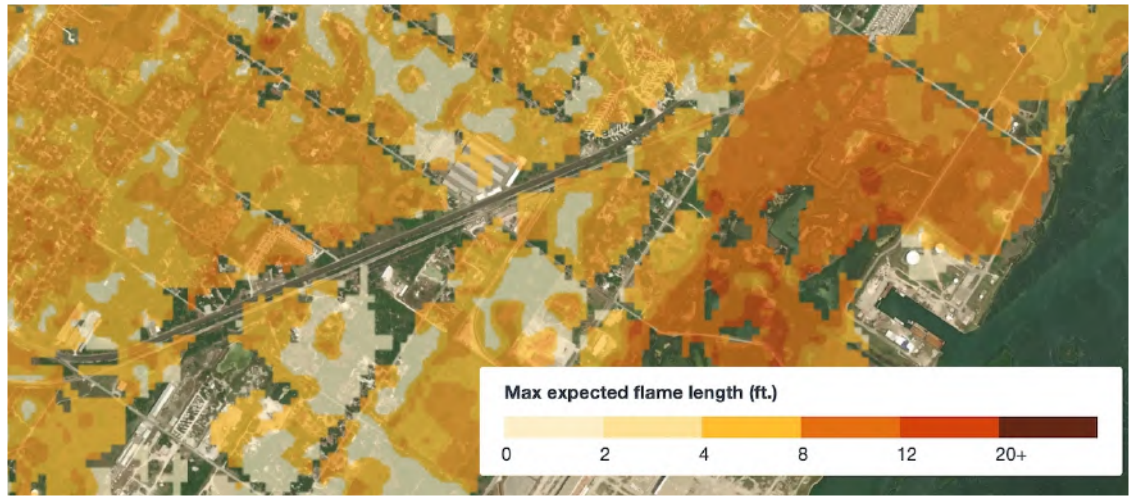
Need some help

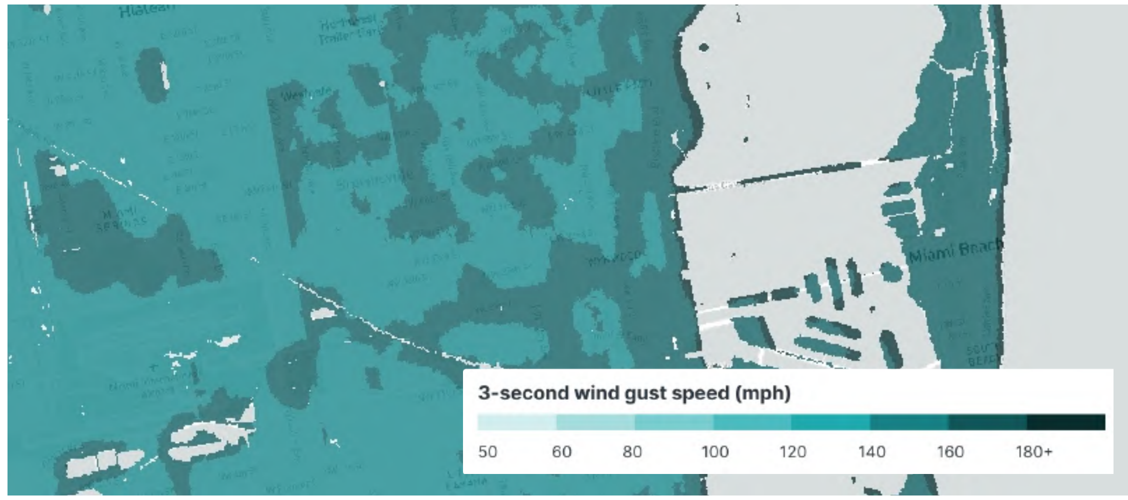
- **Property vulnerability data:** residential data are effectively aggregated from local governments by private industry. However, vulnerability data for other property types (e.g. commercial real estate) is difficult to find and limits our overall understanding of climate risk.

- **Claims data:** limited claims data at aggregate level are available from Federal Gov (e.g. FEMA NFIP). However, industry sources of property-specific losses are nonexistent, and property-level data are unavailable from Feds. For more accurate financial loss models, we need a solution for secure, protected access to individual claims data from government and/or industry.









FIRST STREET FOUNDATION

Discussion

Transparency and Reproducibility

The best products and models are created through the Open Science process and is the only way for banks and regulators to truly know **what they are using** and **how to use the data** properly. This furthers the trust in public disclosures related to climate risk.

Flood Model - 3 Meter Resolution

- Read the full 2020 technical methodology here>
- Read the peer reviewed paper from water resource research here>
- Read the 2022 flood methodological updates here>
- Report: The first national flood risk report>
- Report: The cost of climate, America's growing flood risk>
- Report: Infrastructure on the brink>
- Report: Climbing commercial closures>
- Read the peer reviewed paper from Natural Systems and Earth Systems Sciences on simulating historic floods>
- Read the peer reviewed paper from Journal on Hydrology on precipitation and IDF curves>
- Read the peer reviewed paper from Information Processing & Management on historical floods and adaptation methods>
- Read the peer reviewed paper from ASCE on pluvial damage functions>
- Read the peer reviewed paper from Frontiers in Water on commercial damage functions>
- Read the peer reviewed paper from Climate on property level damage>
- Read the peer reviewed paper from Environmental Research on riverine damage functions>

Wildfire Model - 30 Meter Resolution

- Read the full 2022 technical methodology here>
- Read the peer reviewed research published in the journal fire>
- Report: Fueling the Flames>

Wind Model - 30 Meter Resolution

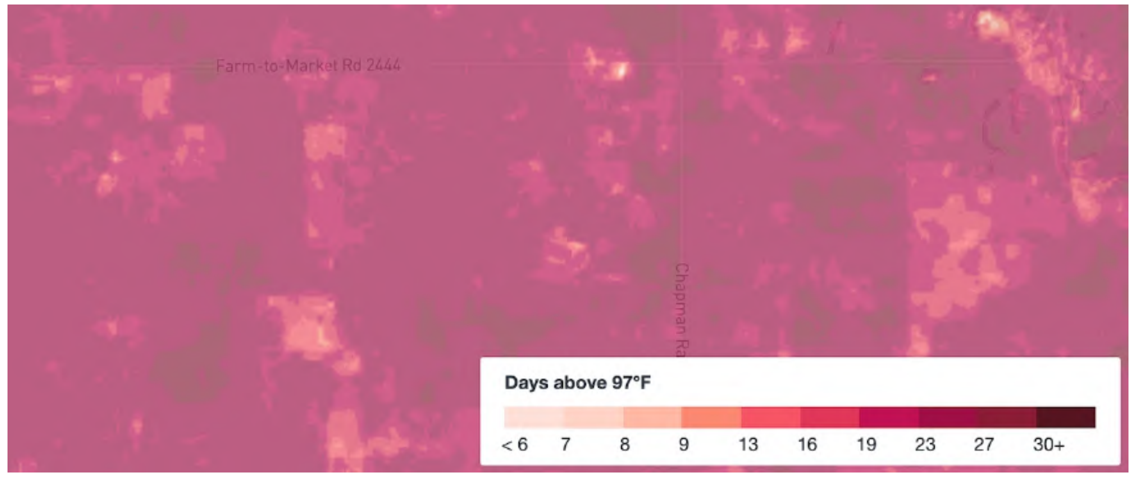
- Read the full 2022 technical methodology
- Read the peer reviewed research published in the AMS journal
- Report: Worsening Winds

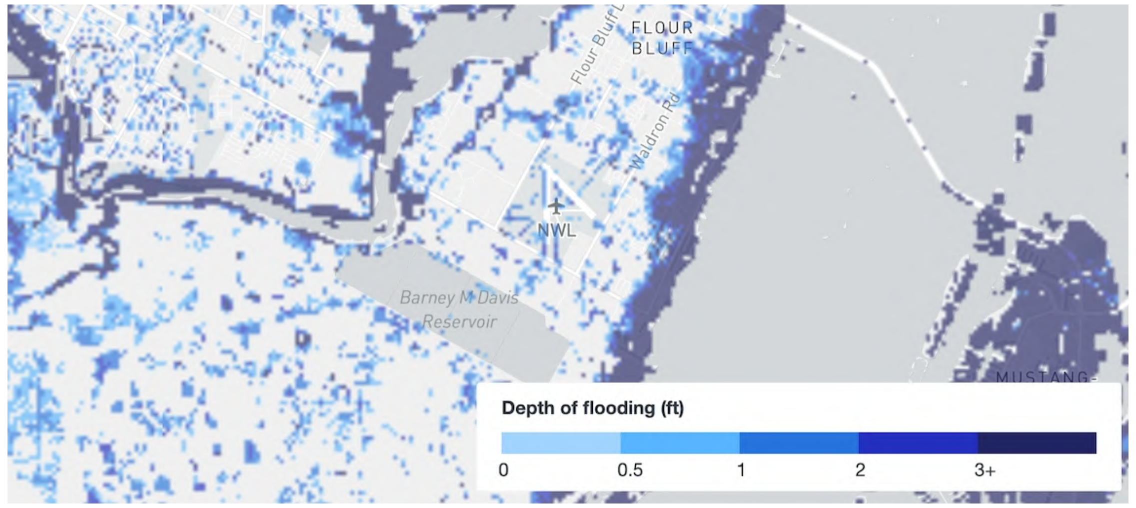
Extreme Heat Model - 30 Meter Resolution

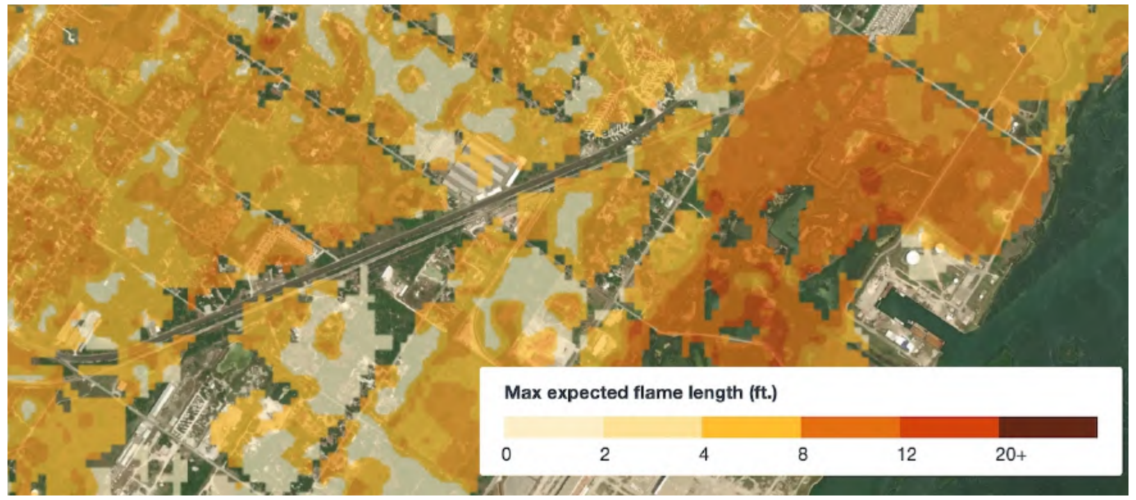
- Read the full 2022 technical methodology here>
- Read the peer reviewed paper from the journal climate here>
- Report: Hazardous Heat>

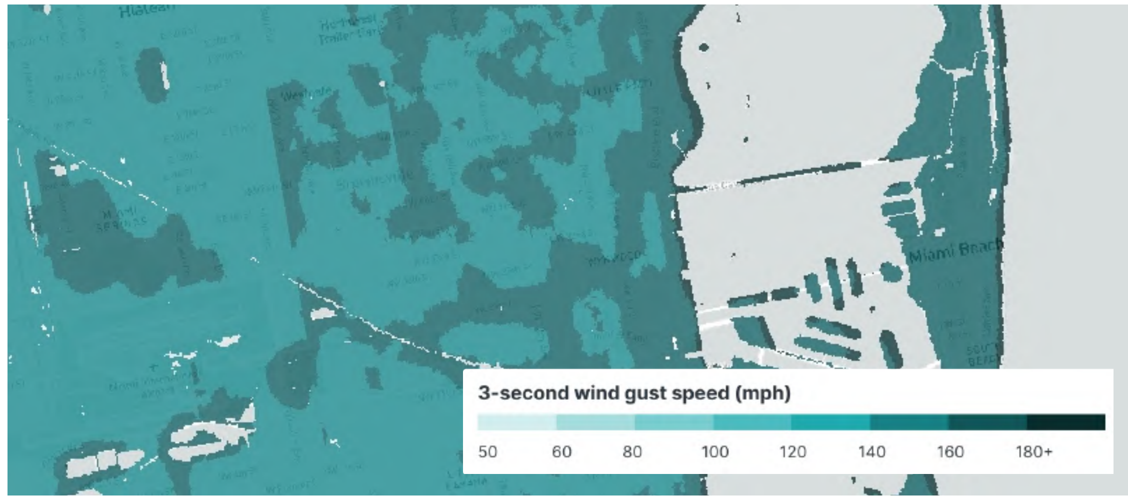
Climate Implications Publications

- Read the peer reviewed paper from Risk and Financial Management on the impact to property values from FEMA flood zone designations
- Read the peer reviewed paper from AAAG on flood inequities
- Read the peer reviewed paper from Nature on inequitable flood. risk patterns
- Read the peer reviewed paper from PRPR on tidal flooding impact to real estate
- Read the peer reviewed paper from Nature on unpriced climate risk

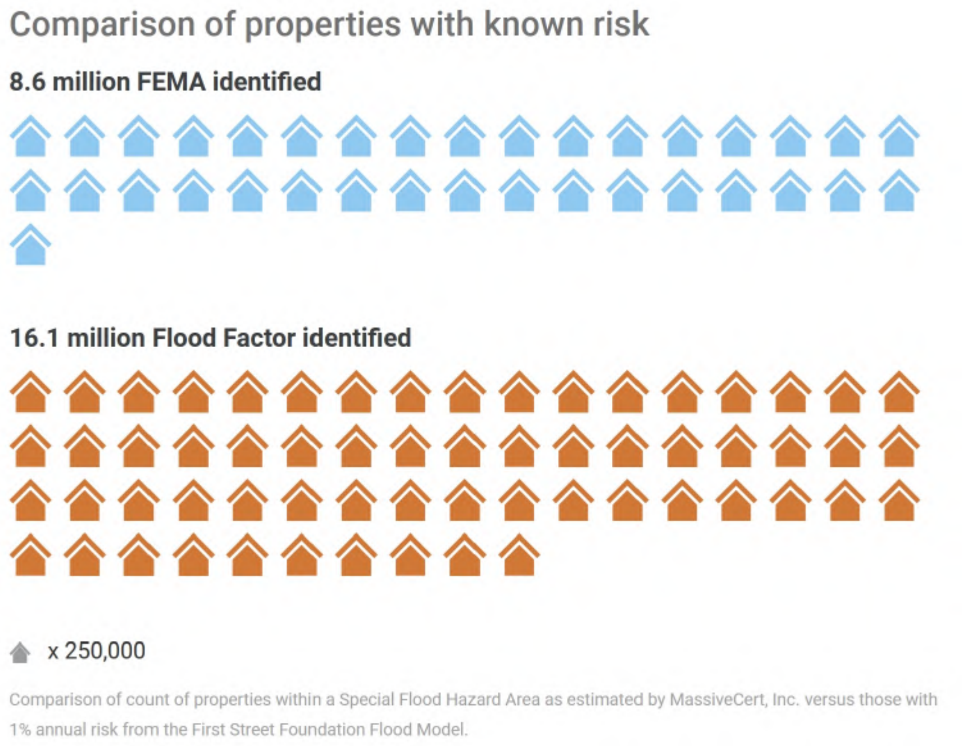


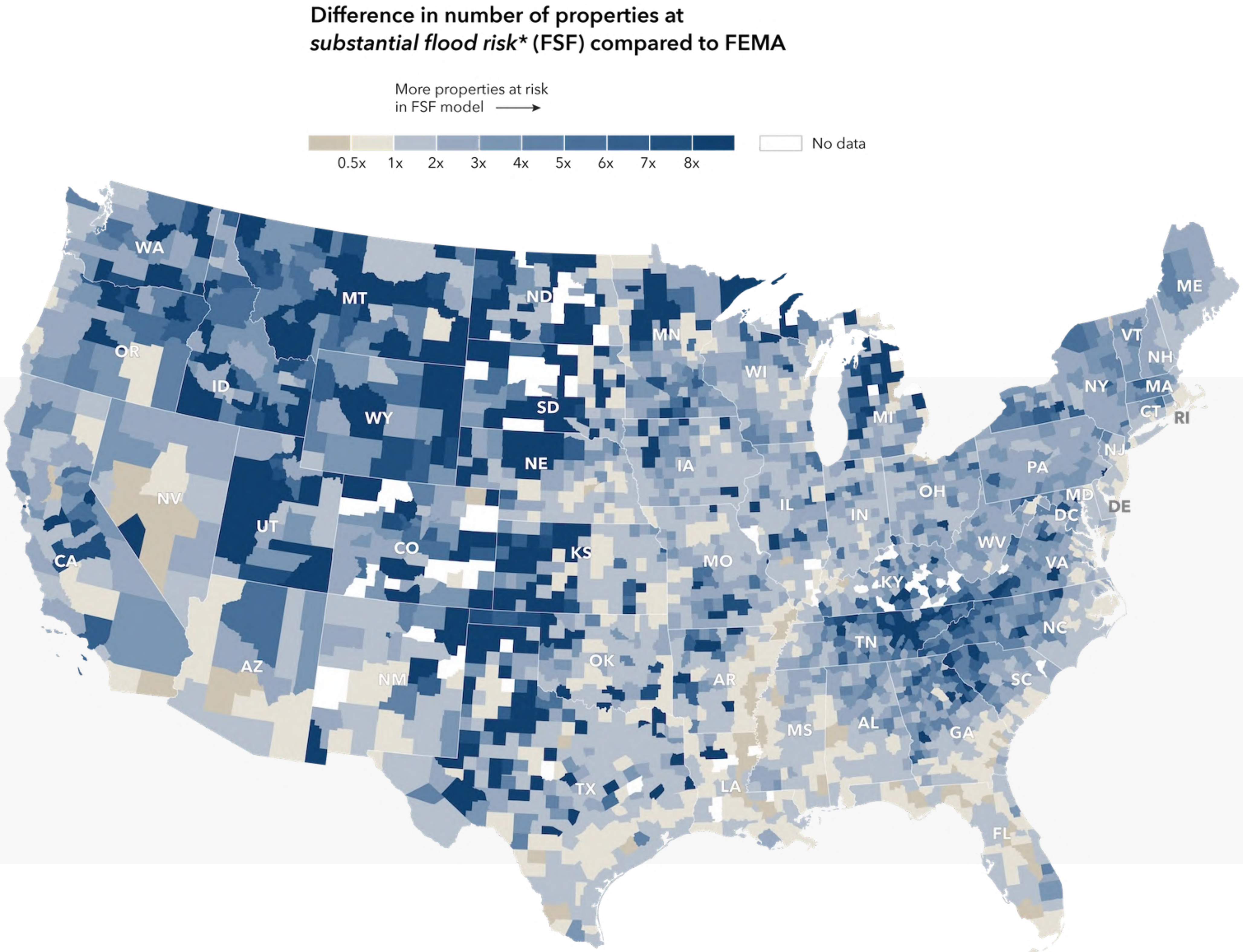






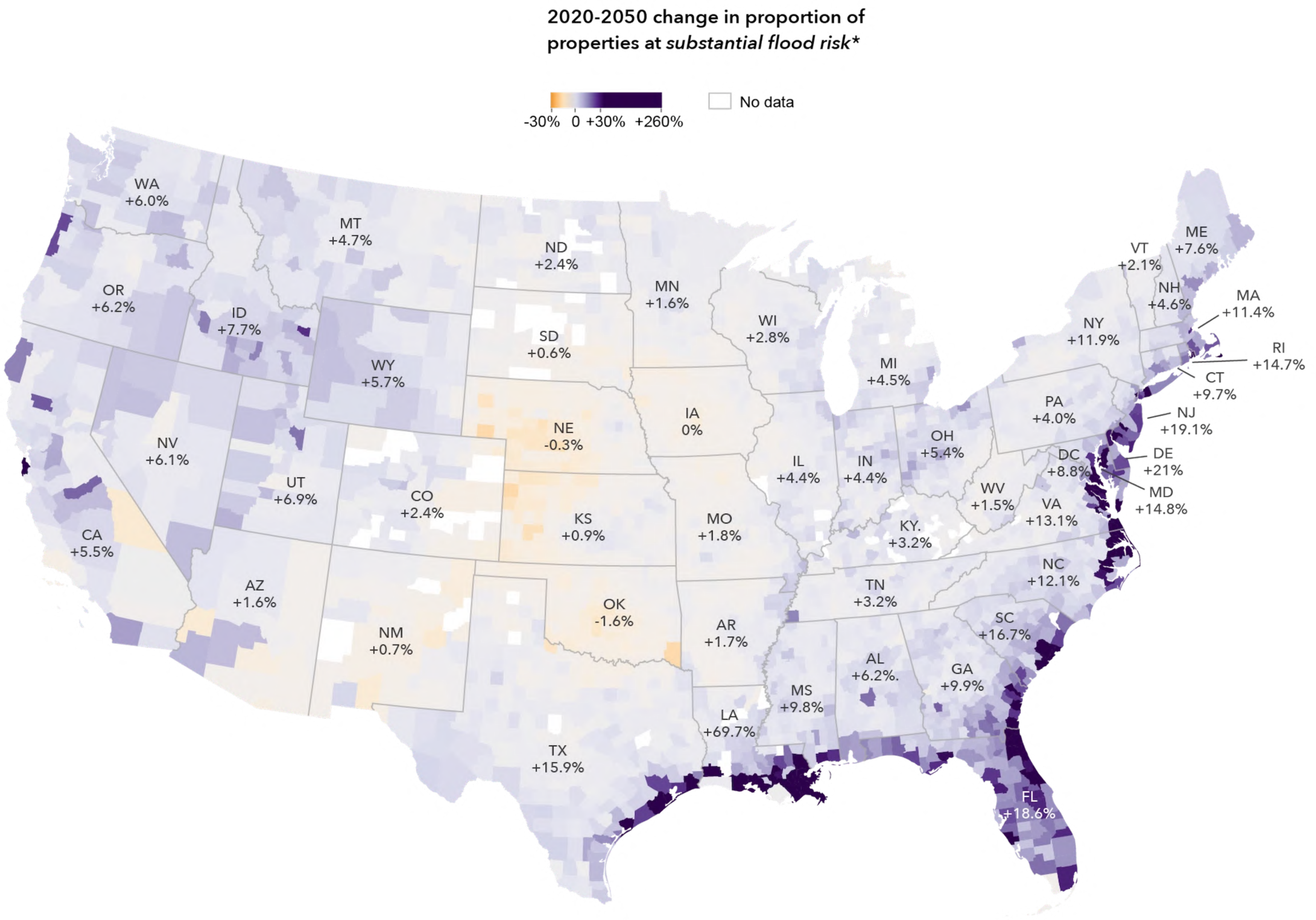
Comparing First Street Foundation results to FEMA.





We estimate future risk - flood

The model uses CMIP5 RCP4.5 results to estimate how flood risk will change as the climate changes. In 2050 overall, the model shows an additional 10.9% or 1.6 million properties as having 1% or greater annual risk of flood by 2050.



* Substantial risk is calculated as inundation 1 cm or more to the building in the 100 return period (1% annual risk)