Managing Physical Climate Risk in the Municipal bond Market

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Agenda

- **Introduction to Intercontinental Exchange® (ICE)**

- **ESG Overview**

- **Municipal bond market overview**

- **Solving the problem of modeling physical risk to Municipal Bonds**

- **Example bond issuances**

Who are we?

Intercontinental Exchange® (ICE)

- Background information outlining the core business and focus of ICE can be found at, [About Us | ICE](#). In short, ICE business focus is around operating global financial exchanges and clearing houses and providing mortgage technology, data and listing services

- More recently, driven by the risQ acquisition, much focus has centered around adding many more ESG metrics to the current ICE product suite. risQ has become a broad department within ICE, called, "Data Innovation and Impact", or **DIIT** for short

- ****risQ Inc, a startup originating from Northeastern University's Sustainability and Data Sciences (SDS) Laboratory, funded by the National Science Foundation

ESG Overview

Key notes:

- "ESG", what does it mean?
  - Environmental (Impacts on built environment)
    - Physical climate risk, carbon use, transition risk from current energy use, pollution and migration
  - Society (Impacts on society, communities)
    - All aspects of social equity and justice, health and environment impacts on Individuals
  - Governance (Oversight of SG)
    - Leadership and guidance, sustainability and oversight of E & S

- **Focused on encouraging responsible investing. Can be aimed at individuals, companies or governments**
- **Really, comes down to informed investing! Guide investment decisions towards environmentally and socially focused investments**

Key question: How can we develop and apply ESG metrics to investments, namely Municipal Bonds? Particularly assess the likely impact from physical climate risks?

Municipal Bonds Market Overview

Introduction and Importance of Bond Market

- The municipal bond market, of around **four trillion in overall size**, serves a vital function. Drives investment in critical services. Example include:

Type	Sub-types
Airport	
Charter School	
City	Includes cities, county subdivisions, and incorporated places
Continuing Care Retirement	
Community	
County	
Higher Education	
Hospital	Children, General Acute Care, Clinics, Long Term Care, General, Psychiatric, Rehabilitation, Women
Housing	Apartment, Multi-family, single family
School District	Elementary, Secondary, Unified
Special Purpose	Athletic center, Hotel, Industrial, Museum, Office, Prison, Public building, Recreation, Research center, Sports, Theater
Specials & Dirt Deals	CDD, CFD, Community College District, Dirt deal, Economic development, Metropolitan district, MUD, Redevelopment, WCID
State	
Transit	Bridge/tunnel, Streets highways, toll road, transit stop buffer (a transit system route including areas within a short distance of each stop)
Utility	Combined utility, Electric public power, Fire district, Flood control/storm drain, Gas, Sanitation, Utility, Water/sewer
Ports	

- **Two thirds** of infrastructure projects in the U.S. are financed by municipal bonds

- Over 80,000 state and local governments exist in the US

  - **50,000** have issued municipal securities

- At any given time approximately **one million** securities are in place

Municipal Bonds – Keys to Physical Risk Modeling

- Bonds are repaid through what are called "Revenue Generating Assets", a few examples are:
  - Local residential and/or commercial property taxes
  - Users of infrastructure – toll roads
  - Hospital service districts – numbers of patients
- Bond revenue-generating-assets can be represented spatially
  - State, county boundaries' relatively straight forwards
  - Airport, hospital other discrete locations require development of catchments
  - Laborious hand digitization of complex polygons
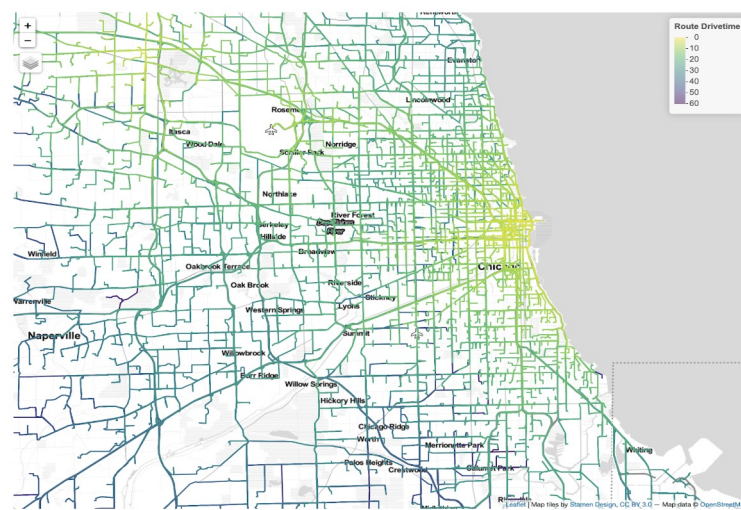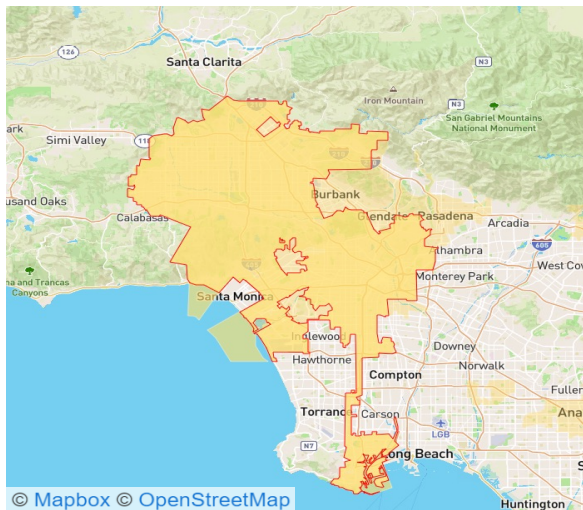
- Discrete location catchment areas: walking, biking, driving, public transit, and multi-modal combination
- Referred to as drive time polygons or isochrones
- This enables estimation of climate impacts by modeling damage to customer populations that fall inside catchment areas, even if business facilities are not directly damaged

What is a Physical Climate Risk Model?


Current climate state

Future climate state
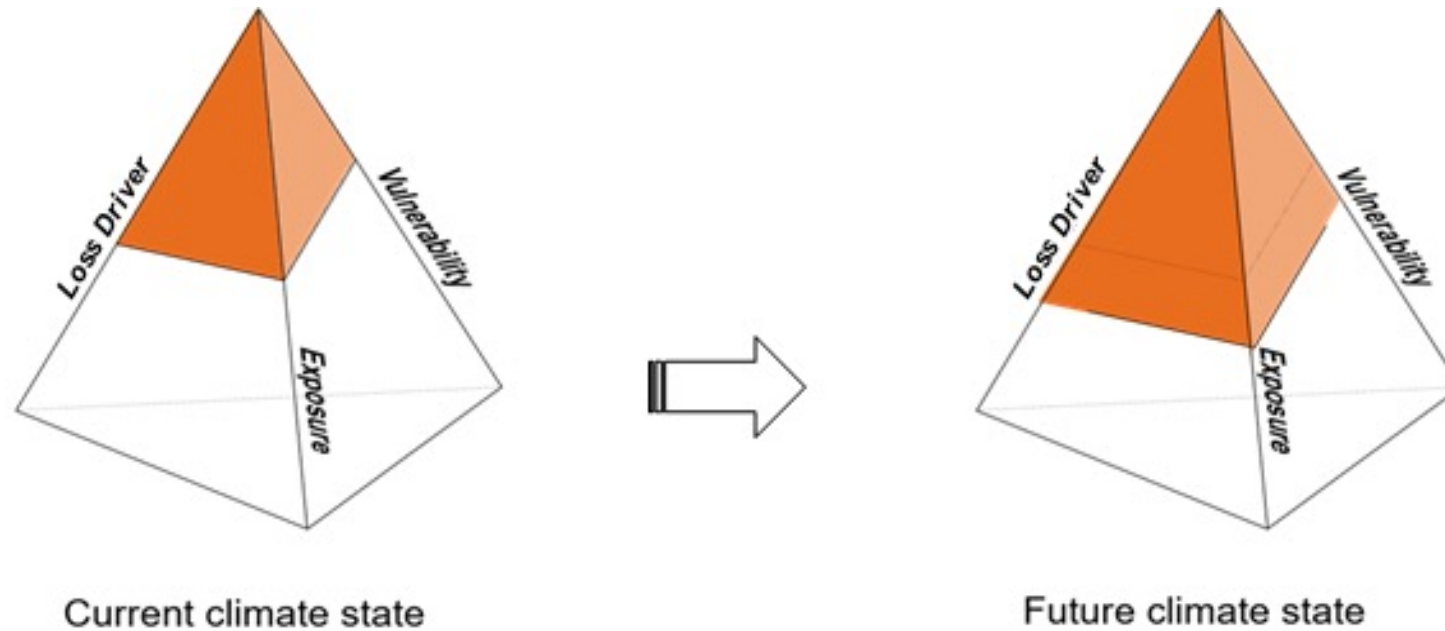
Outputs from any model can be rolled into many forms of loss metrics and scores at any arbitrary geographic level

- **Loss driver**; can be any form of hazard, from physical impacts of natural hazards to climate migration
- **Exposures**; anything of perceived value that is vulnerable to one, or multiple loss drivers
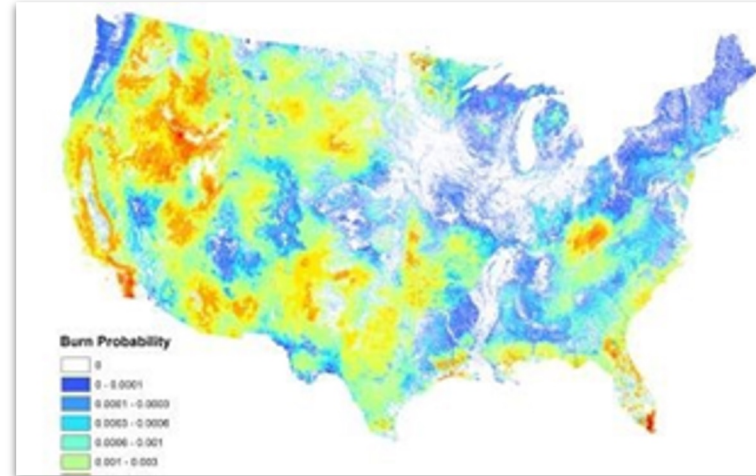- **Vulnerability**; determines the consequences of loss drivers' impact on exposures

Modeled Hazards

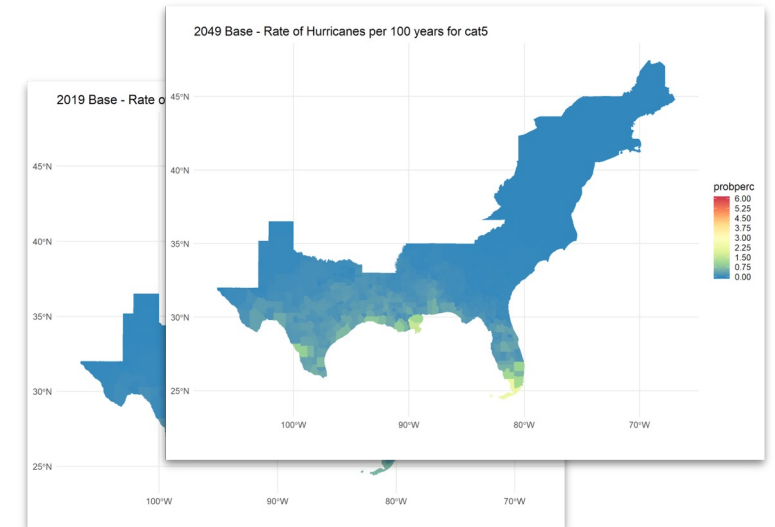All impactful hazards are currently modeled for the coterminous US

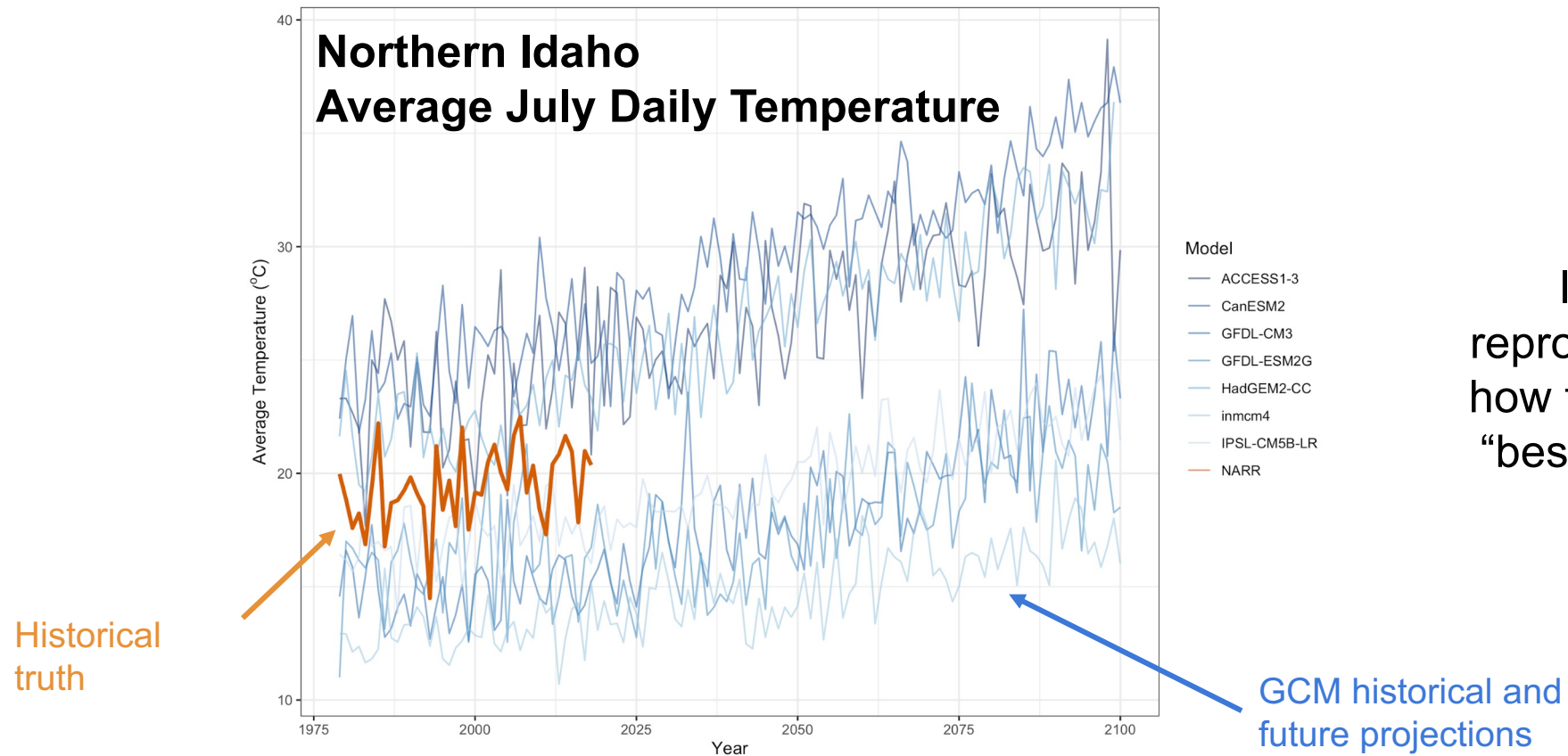**Flood (Coastal, Pluvial, Fluvial)**
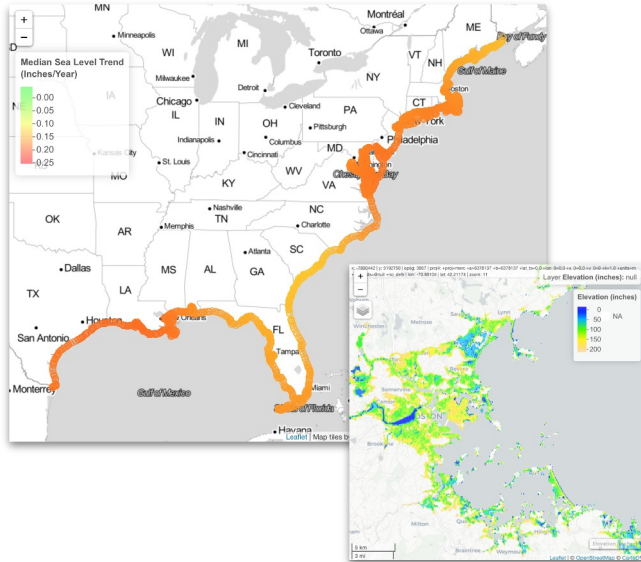
■ Wildfire

Hurricane wind, storm and precipitation induced flood

- Climate conditioning carried out for all models to enable estimates of current, 2020, and future, 2040 and 2060 changes in hazard return periods and intensity from RCP 4.5 AND 8.5 projections

- Climate conditioning involves simulating hazards under future climate scenarios. The results of the model reflect changes in temperature, relative humidity, amount and intensity of precipitation for example
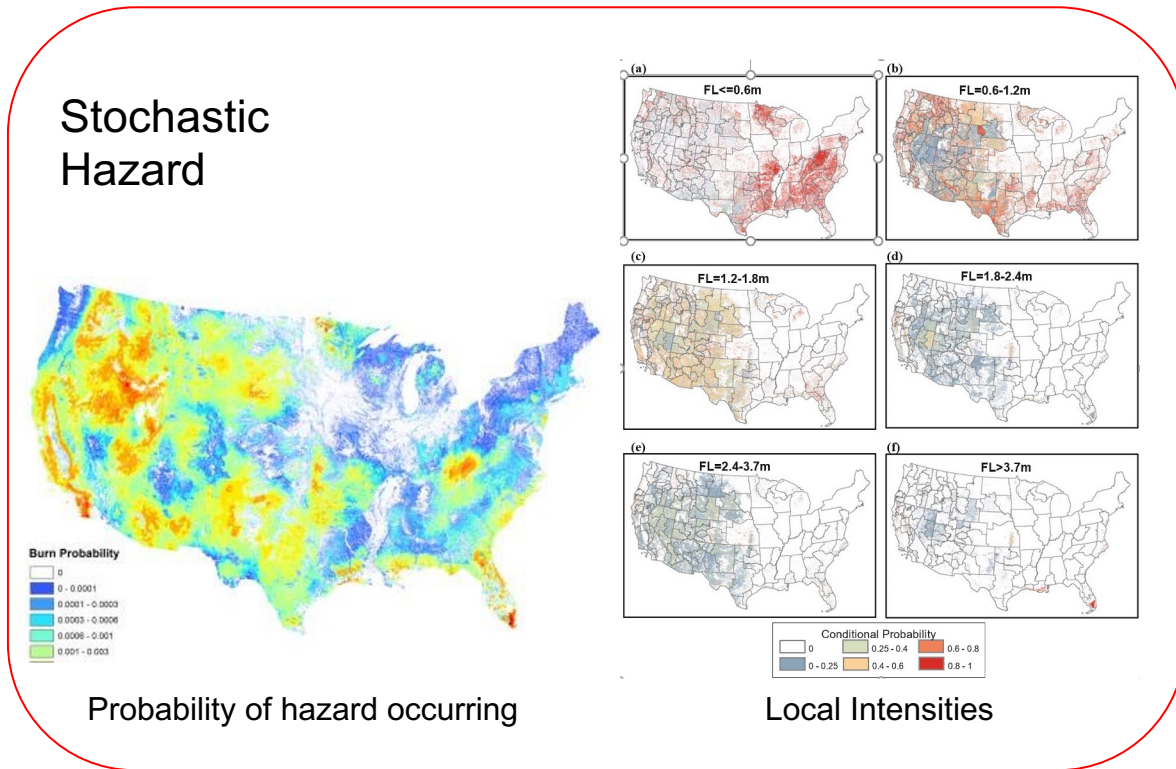
Climate Conditioning Methodology

Northern Idaho
Average July Daily Temperature

Historical truth

GCM historical and future projections

Model
- ACCESS1-3
- CanESM2
- GFDL-CM3
- GFDL-ESM2G
- HadGEM2-CC
- inmcm4
- IPSL-CM5B-LR
- NARR

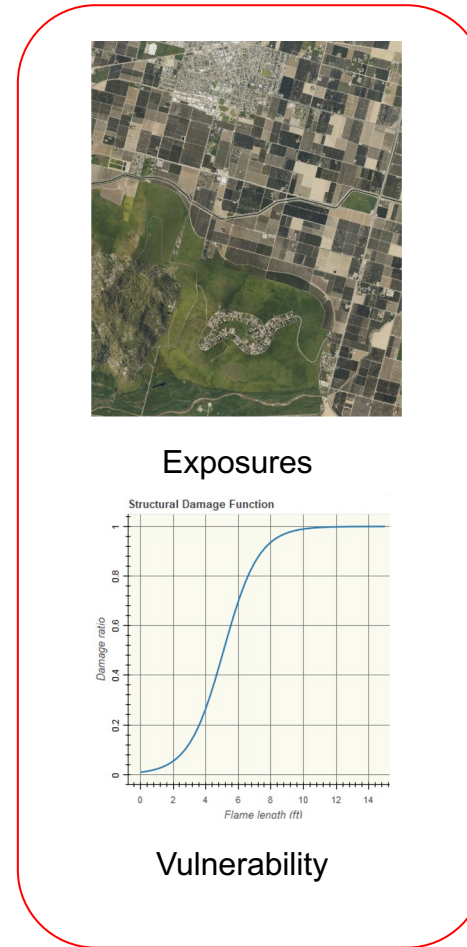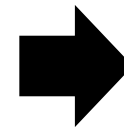If no single GCM reproduces the past, then how to do you choose the "best" GCM prediction of the future?

- Model the historical bias in the GCM models

- Use the combination of future projections and historical bias models to simulate thousands of time series out to 2100

- Look at the distribution of simulations to get a better estimate of the range of possible futures
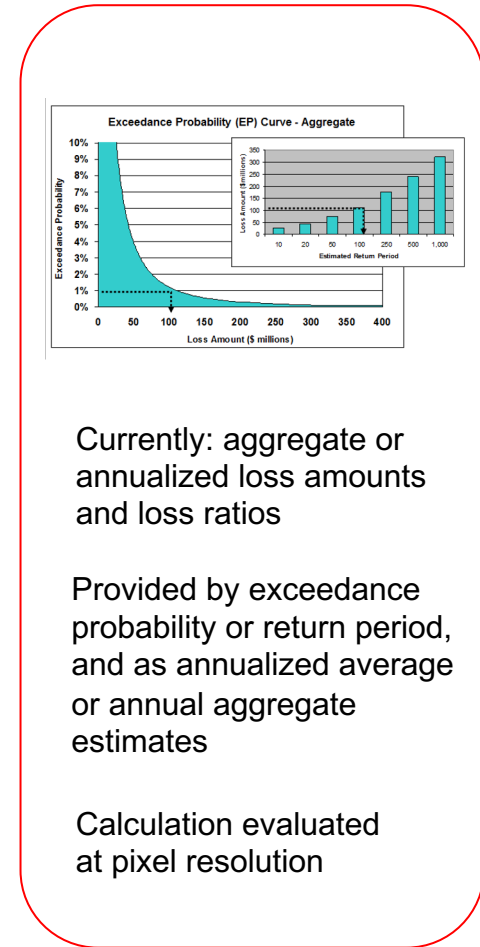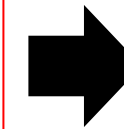
Physical Climate Risk Modeling

- Physical risk model example - Wildfire

Stochastic Hazard

Probability of hazard occurring

Local Intensities

Distinct Hazard for current base year 2020, RCP 4.5 2040 & 2060, and RCP 8.5 2040 & 2060

Exposures

Vulnerability

Damage Estimation

Currently: aggregate or annualized loss amounts and loss ratios

Provided by exceedance probability or return period, and as annualized average or annual aggregate estimates
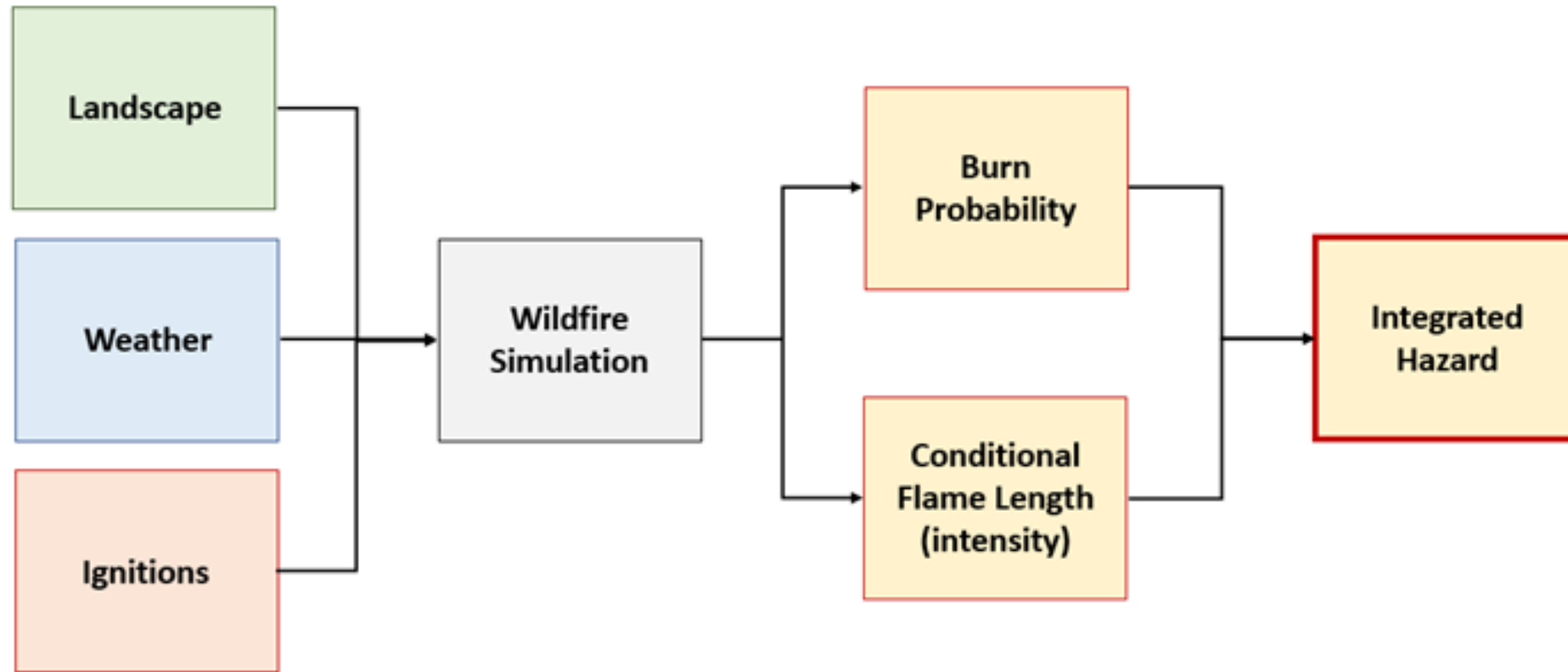
Calculation evaluated at pixel resolution

Loss Metrics

# Landscape Fire Simulation Models (LFSMs)

Landscape Fire Simulation Models (LFSMs)

- FSim consists of modules for weather generation, and for modeling of fire occurrence, fire growth, and fire suppression. The system is designed to simulate the occurrence and growth of fires for thousands of years in order to estimate average burn probabilities and fire size distributions

# National Fire Danger Rating Index (ERC)

Anatomy of an ERC Chart
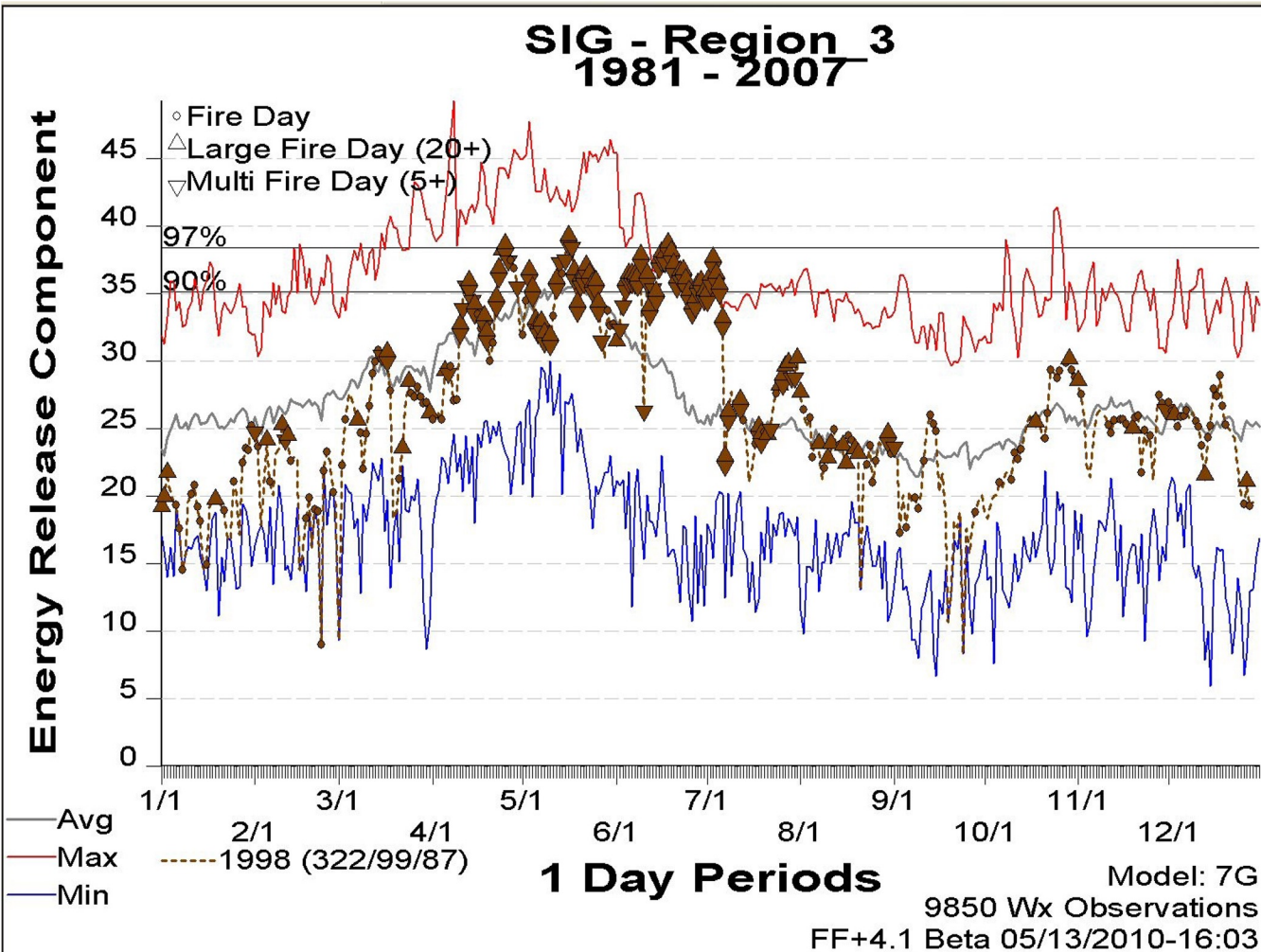
- Energy Release Index ERC, is highly predictive of large fire active

- The ERC index includes the key fire weather variable:
    - Temperature
    - Relative humidity
    - Precipitation
    - Various fuel moisture models

- ERC can be readily created for current and future climate horizons and scenarios, by applying climate conditioning to current climate. Results in future views of wildfire likelihood

- Climate conditioned future ERC streams can be used to simulate many thousands of wildfire events representing future years
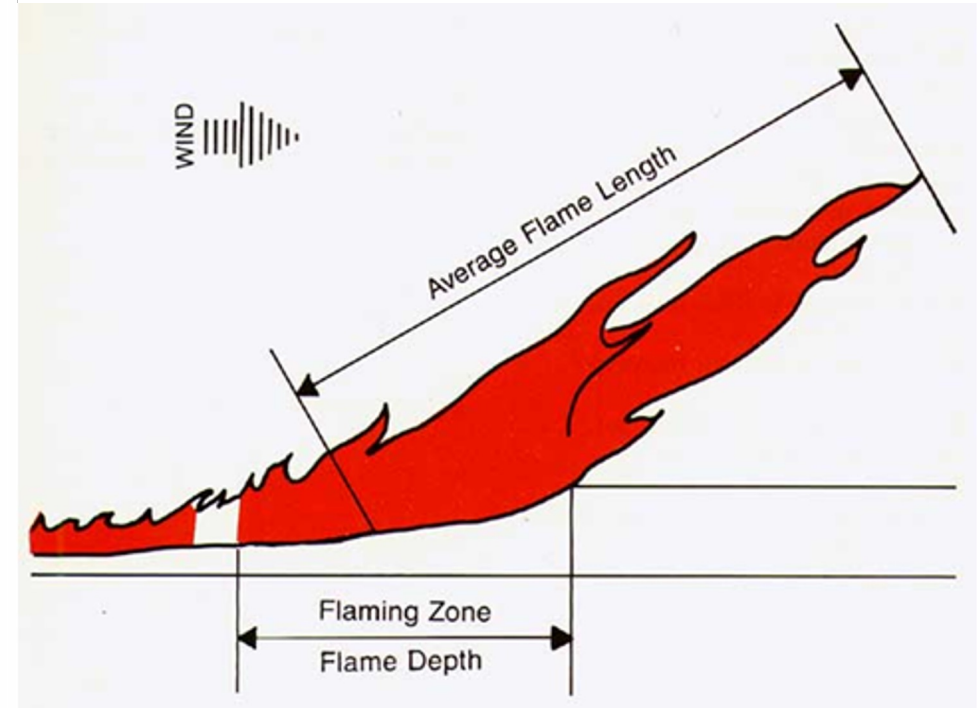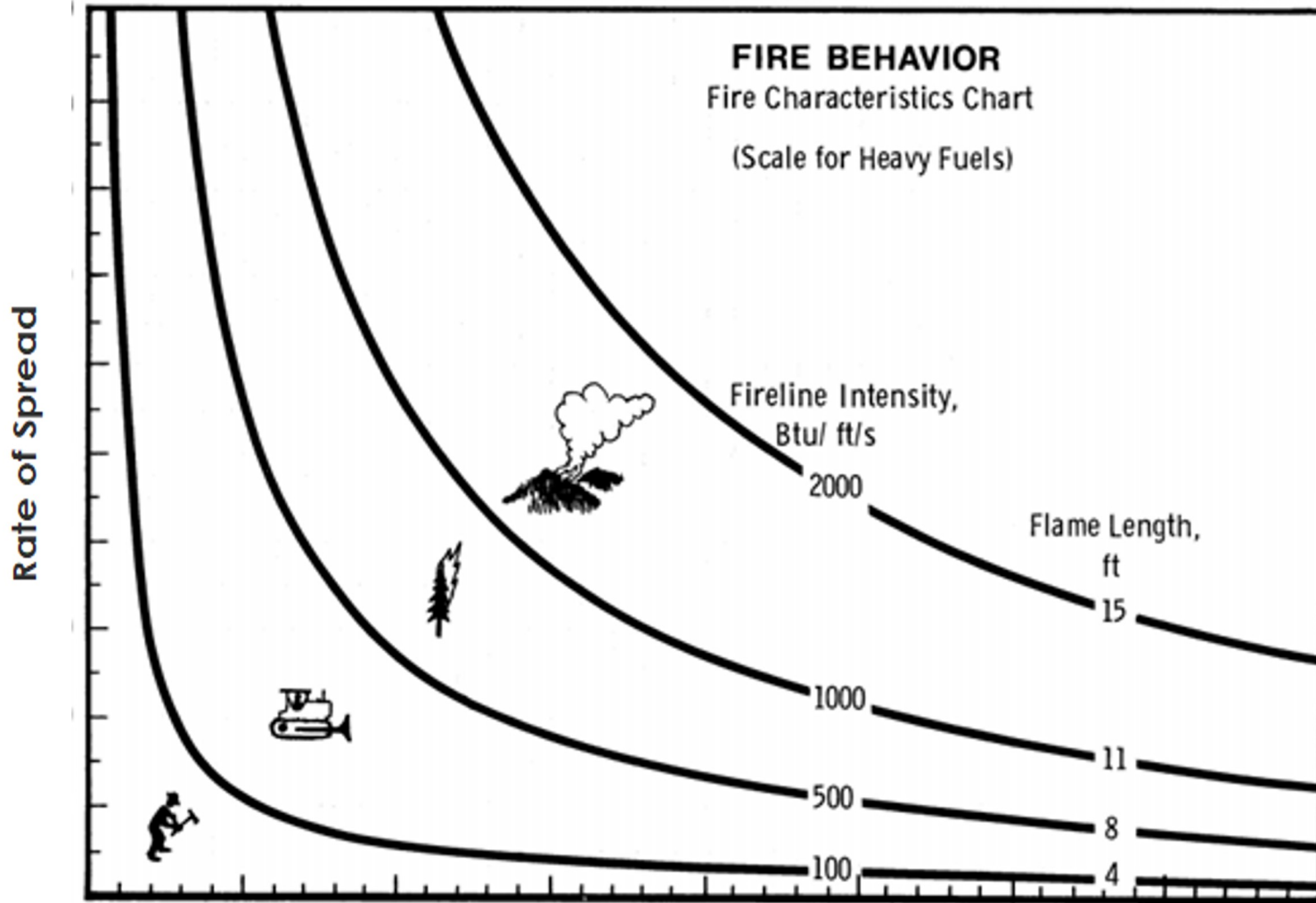
Physical Climate Risk Modeling

- Climate induced wildfire burn probability changes
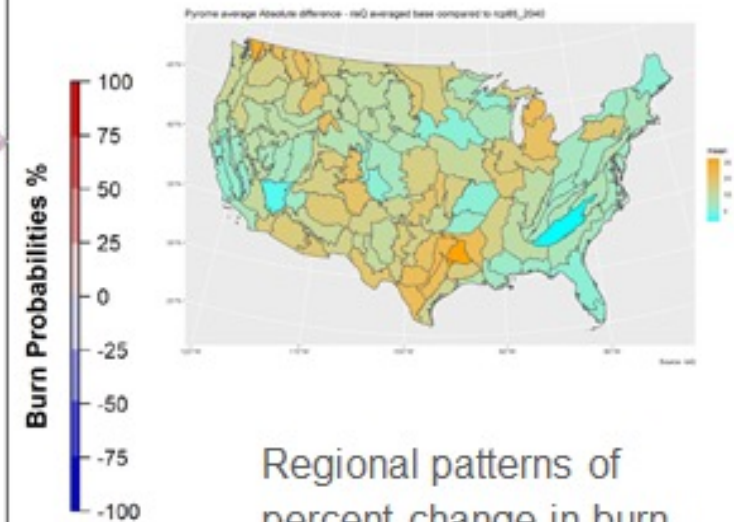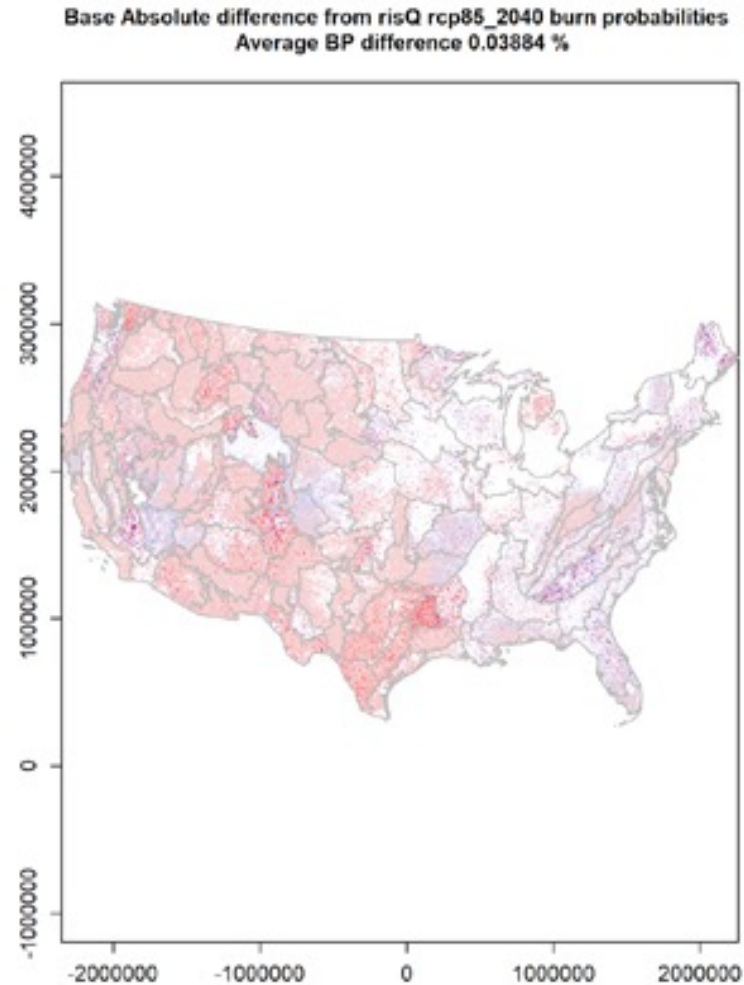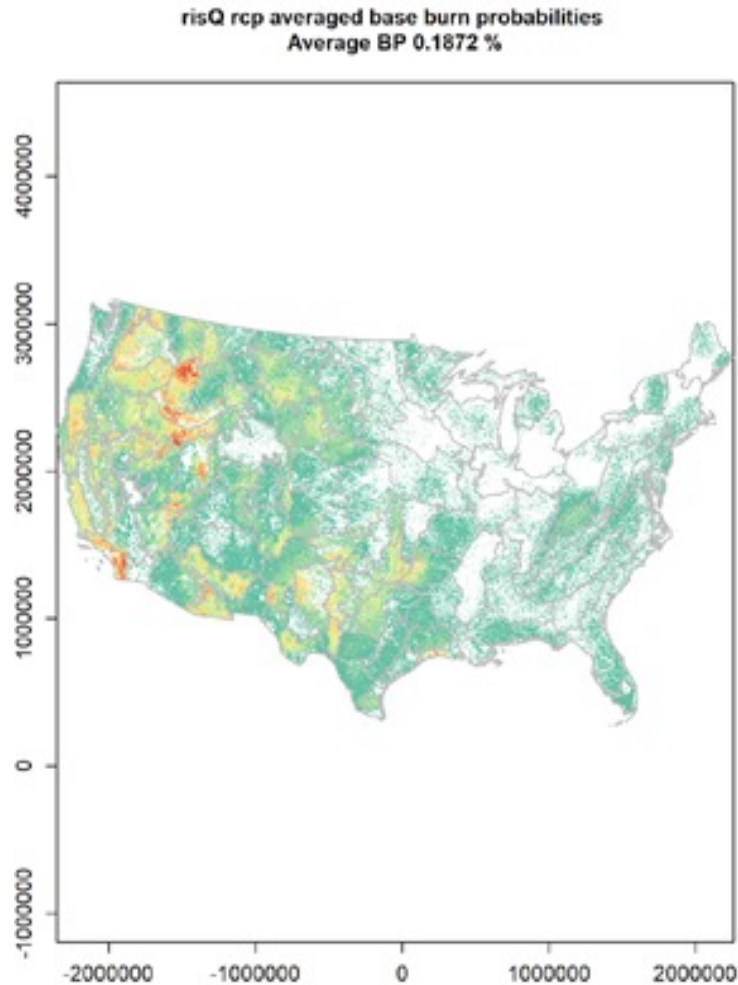
Regional patterns of percent change in burn probabilities, average change by pyrome

Physical Climate Risk Modeling

- Wildfire vulnerability rational

FIRE BEHAVIOR
Fire Characteristics Chart
(Scale for Heavy Fuels)

Fireline Intensity, Btu/ ft/s
2000

Flame Length, ft
15

1000

11

500

8

100

4

Rate of Spread

WIND

Average Flame Length
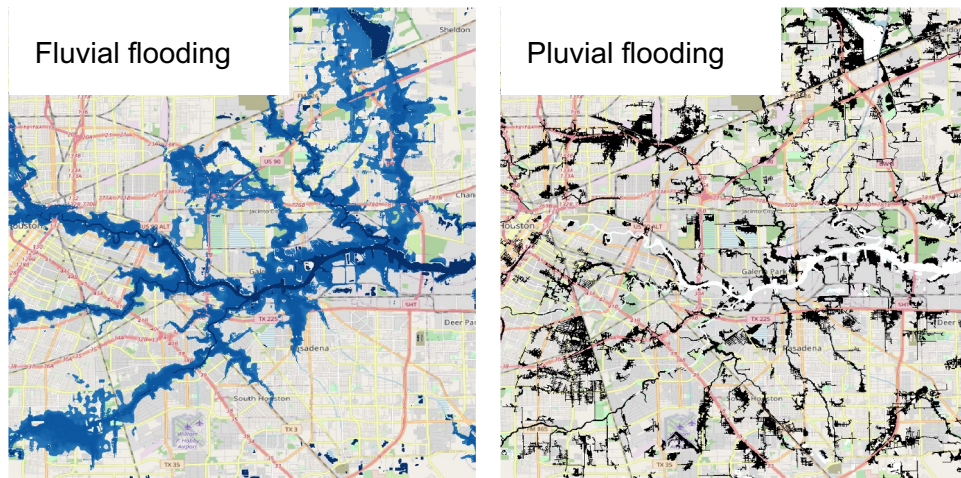
Flaming Zone

Flame Depth

Annotation highlighting flame length

Rothermel, USFS/DOE intensity/spread prediction charts. Highlight the levels of flame length and requirements to fight fire.
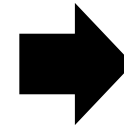
Physical Climate Risk Modeling

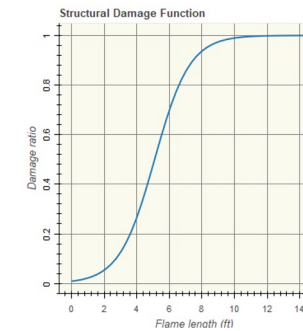- Physical risk model example – Inland Flood
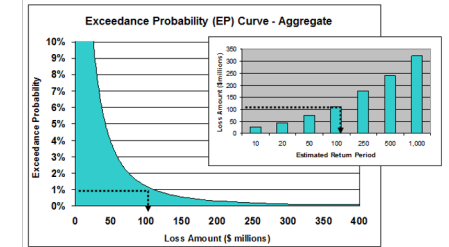
Stochastic Hazard

Fluvial flooding

Pluvial flooding

Return period flood depths

Distinct Hazard for current base year 2020, RCP 4.5 2040 & 2060, and RCP 8.5 2040 & 2060

Exposures

Structural Damage Function

Vulnerability

Damage Estimation

Exceedance Probability (EP) Curve - Aggregate
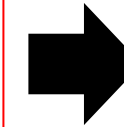
Currently: aggregate or annualized loss amounts and loss ratios

Provided by exceedance probability or return period, and as annualized average or annual aggregate estimates

Calculation evaluated at pixel resolution

Loss Metrics

Municipal Bond Financial Impairment Measures

Delivering Concise, Actionable Data

- Standard loss metrics by bond and occupancy, for both property and GDP, for each year of the bond duration
    - For each climate scenario
        - Return period value at risk (many return periods)
        - Annualized expected loss
        - Etc…..
- **Too much! Clients required 1 number, excel compatible output**
- risQ Scores developed for comparison of bond type relative to specific year and climate scenario. For unique locations and portfolio roll up
    - Flood score – (Inland, coastal, sea level rise)
    - Hurricane score – (Wind, storm surge, hurricane precipitation induced flooding)
    - Wildfire score
    - Total score – Weighted combination of hazard scores
    - Each hazard score is weighted combination of property and GDP
- Score varies from 0 – 5, with financial impairment doubling from by score increment, say 1 to 2 etc
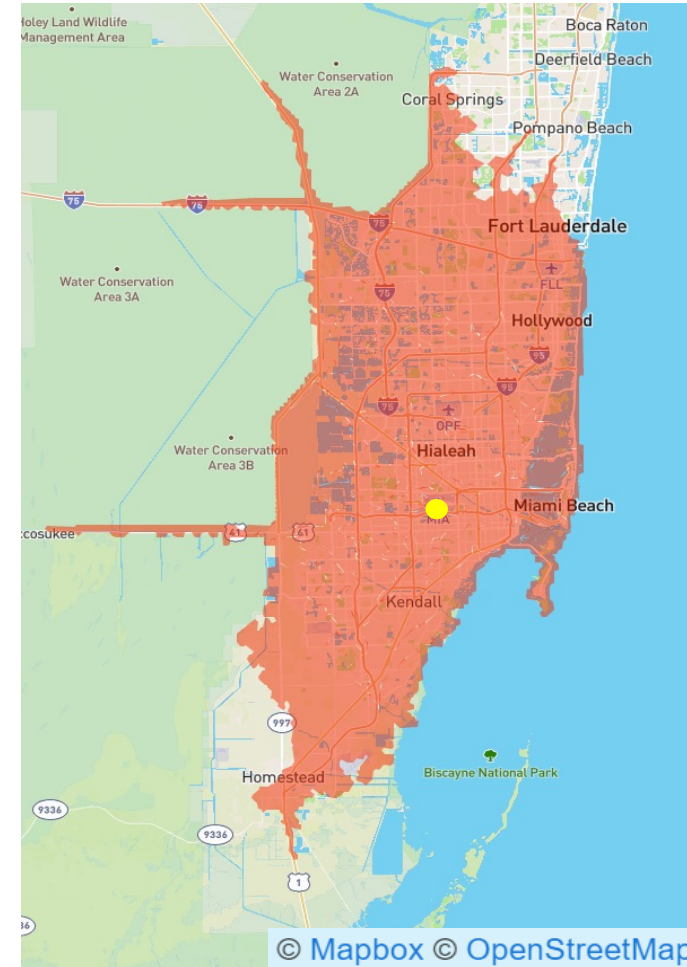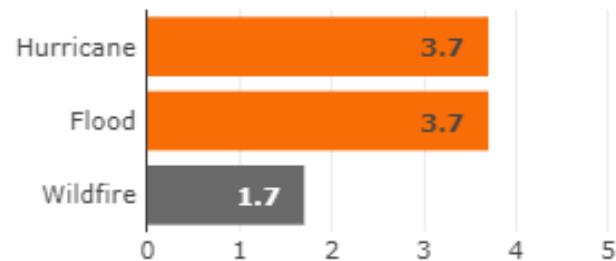
Right image showing a 45-minute drive time isochrone around Miami International Airport. Image below showing this area's risQ scores for year 2030
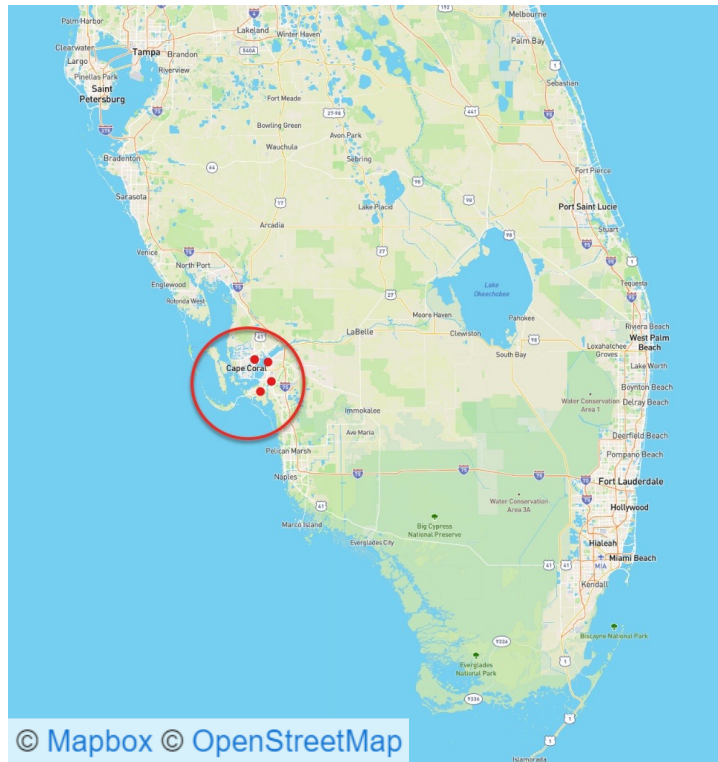

Climate Risk overview

Total risQ Score

4.5

risQ Score Components

Hurricane   3.7
Flood   3.7
Wildfire   1.7

Source of data and image: ICE Data Services 10/3/22

Lee Memorial Health System

- The Lee Memorial Health System operates 4 acute care hospitals around Cape Coral / Fort Myers Florida

Southern Florida with circle denoting the area of the facilities

Health System's risQ Scores out to year 2044

Issuer	Total risQ Score	Hurricane risQ	Flood risQ
Lee Memorial Health System	4.8	4.0	3.4

risQ Scores at 30-minute drive time isochrone
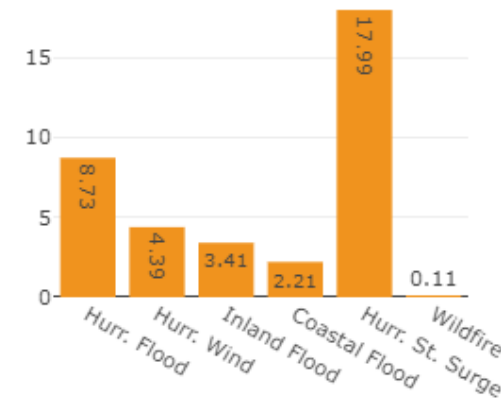*Source of image and data: ICE Data Services 10/3/22*

- Bond series is secured by revenues from obligated facilities located across 4 medical campuses. Lee Memorial obligated group consists of 4 acute care hospitals, a rehabilitation hospital, and a children's hospital

- ICE aggregates the facilities' risQ Scores to provide a single Health System risQ Score

Lee Memorial Hospital

- Lee Memorial Hospital risQ Scores year 2029:
  - Total risQ Score 4.4
  - Hurricane risQ 3.7
  - Flood risQ 3.3

- On right, various hazard metrics are shown as well as the projected GDP impairment & property value-at-risk

GDP

Absolute value at risk
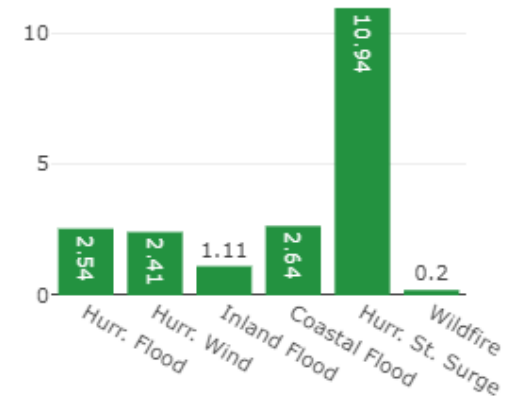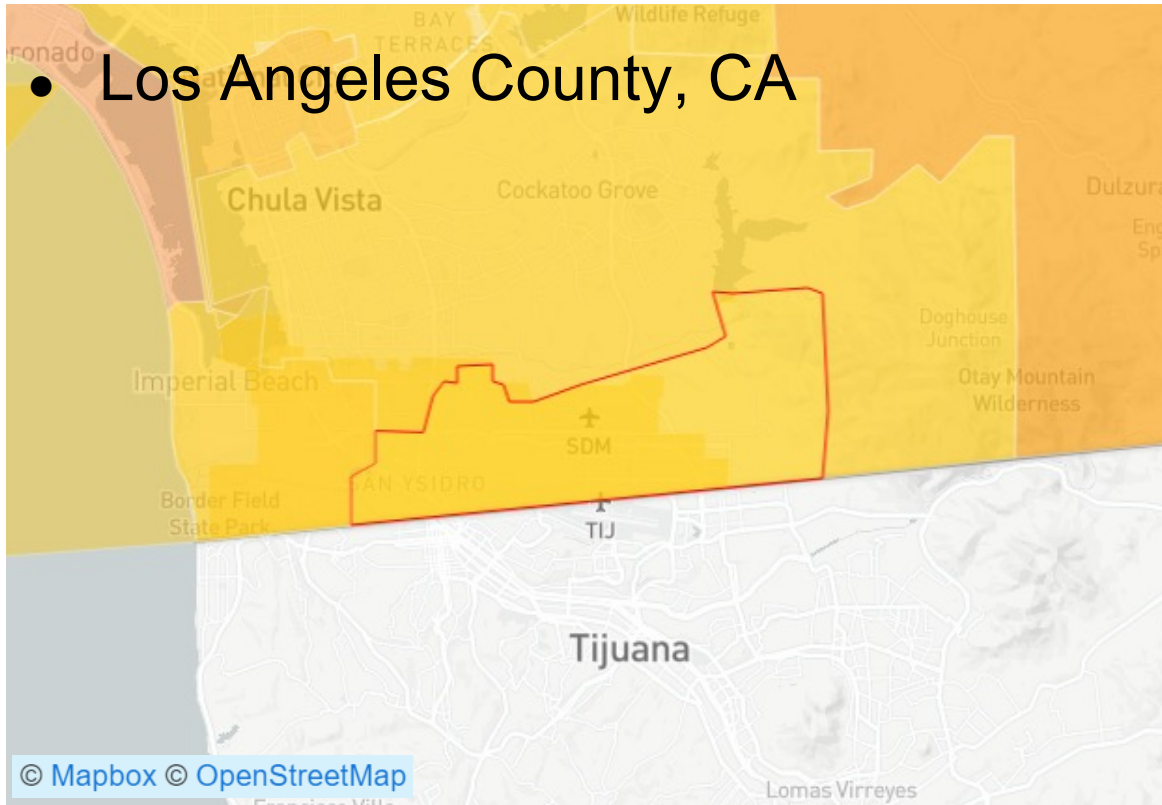
Property Value

Absolute value at risk

Charts above show cumulative value-at-risk within a 30-minute drive time isochrone out to year 2029

Source: ICE Data Services 10/3/22

San Ysidro Elementary School District

- Los Angeles County, CA

Source of image and data: ICE Data Services 10/3/22

Property Value at Risk 2050

Absolute Hazard Breakdown
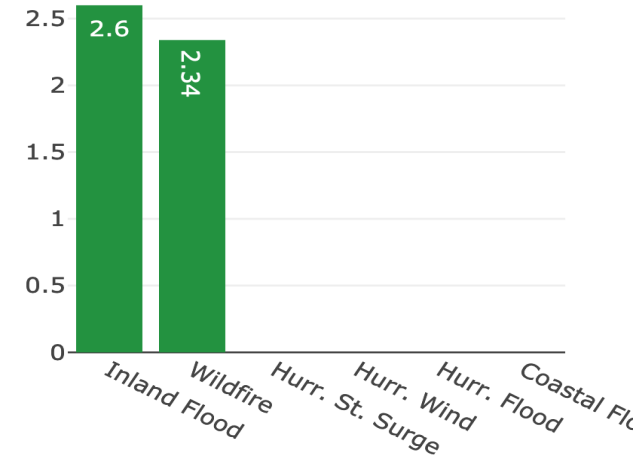
Percentile Hazard Breakdown
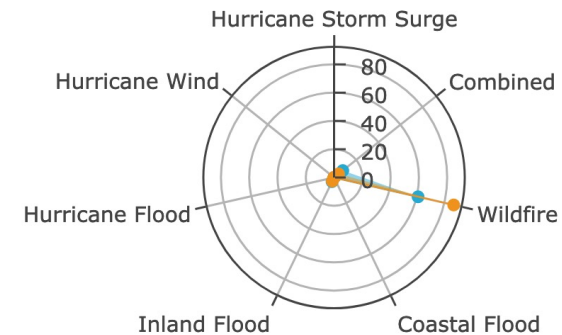
Grand Parkway Toll Road System

- ## Harris County, TX
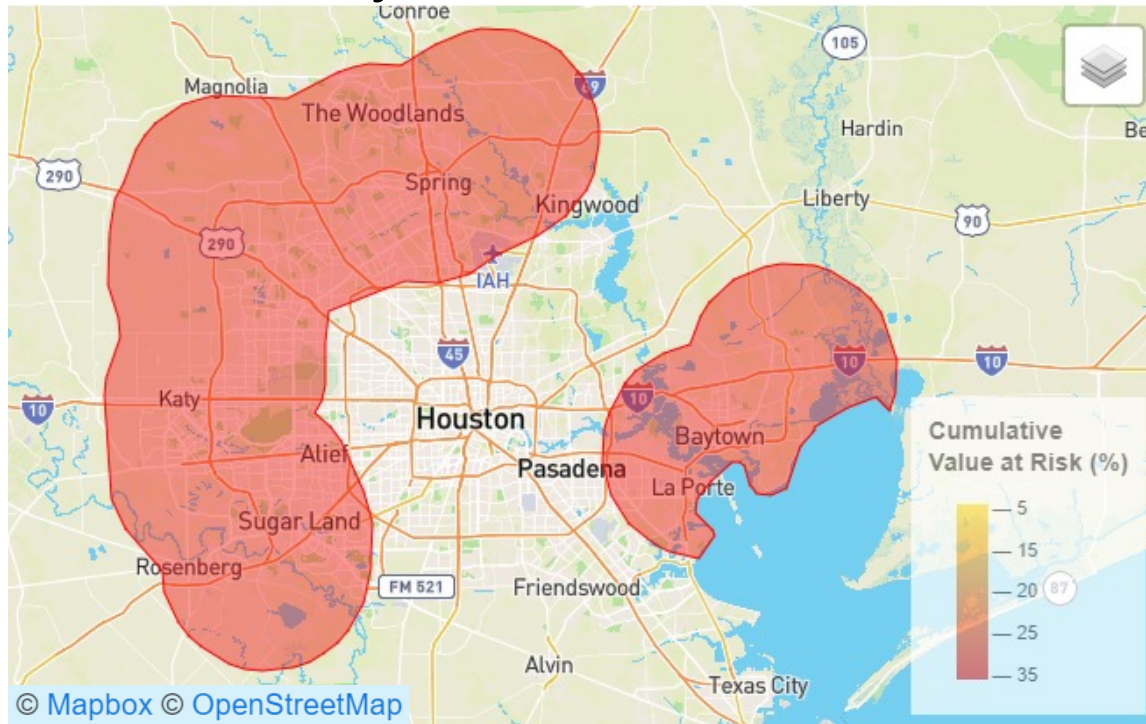
Source: ICE Data Services 10/3/22

- Grand Parkway Toll System is a 186-mile transportation loop outside of Houston. Here we have a 10-mile buffer around the existing roadway to evaluate its risk. The system has submitted design plans to complete the loop

- The primary risk to the system is hurricane precipitation flooding as well as inland flooding risk

Los Angeles Department of Water & Power (LADWP)

- ## Los Angeles County, CA
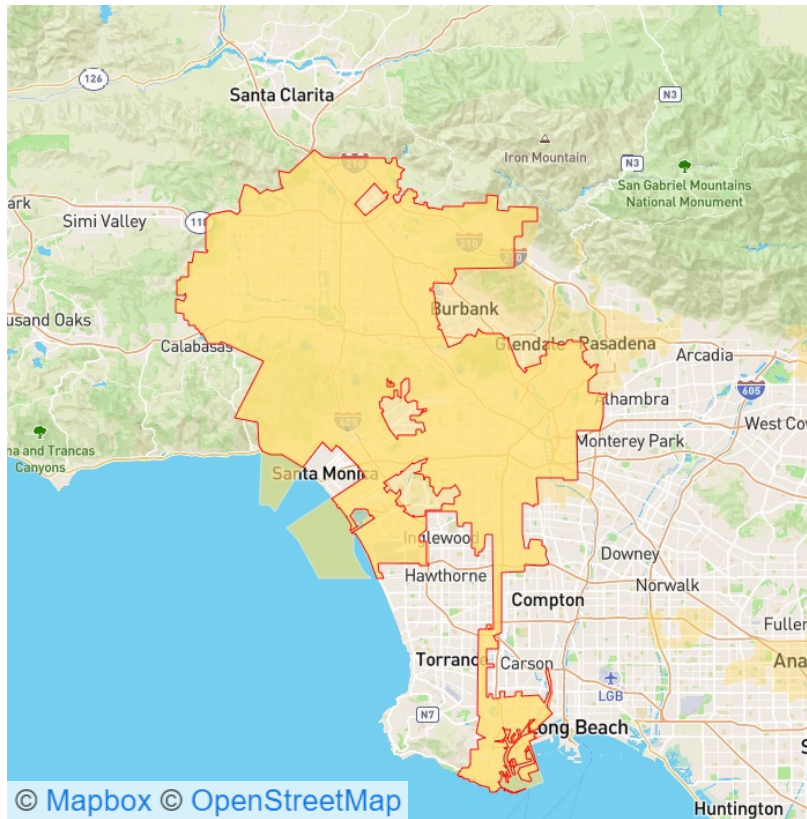
LADWP service area

- LADWP has a Wildfire risQ Score 2.2

- Among utilities nationwide, it is the 85th percentile for projected property value-at-risk (VaR) from wildfires

- Cumulatively, by the year 2032, the projected property VaR from fires within the territory is 1.4%

- A 500-year fire puts up to 11% of property at risk

Source of image and data: ICE Data Services 10/3/22

FEMA's BRIC Program

- In 2022 FEMA announced $2.3 billion available for hazard mitigation assistance programs: Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance grant programs

- BRIC Elevation Criteria prioritizes disadvantaged communities

  - low income, persistent poverty

  - high unemployment, or underemployment

  - racial and ethnic segregation, linguistic isolation

  - high housing cost burden and substandard housing

  - disproportionate environmental burden / high cumulative impacts

  - high transportation cost burden and/or low transportation access

  - limited water and sanitation access and affordability

  - high energy cost burden and low energy access

  - distressed neighborhoods

- Datasets from the US. Census and the American Community Survey can provide relevant metrics to support FEMA BRIC grant applications

Matching BRIC Criteria with Available Datasets

BRIC Elevation Criteria	Corresponding Variable
Disproportionate environmental burden and high cumulative impacts	Ozone Levels (8-hour)
Disproportionate environmental burden and high cumulative impacts	PM 2.5 Exposure
Distressed neighborhoods	Population with Health Insurance (%)
Distressed neighborhoods	High School Graduation Rate
Distressed neighborhoods	Racial Gap in Household Income
High and/or persistent poverty	Median Household Discretionary Income
High and/or persistent poverty	Per Capita Income
High and/or persistent poverty	Living Below Poverty Line
High energy cost burden and low energy access	Income Energy Burden (% income on energy)
High housing cost burden and substandard housing	Average Monthly Housing Costs
High housing cost burden and substandard housing	Average Gross Rent
High housing cost burden and substandard housing	Stressed Renters Incomes Between 35k to 75k (%)
High housing cost burden and substandard housing	Stressed Renters Incomes Less Than 35k (%)
High housing cost burden and substandard housing	Overcrowded Housing (% rooms >1 occupant)
High transportation cost burden / low transportation access	Commute to Work Greater Than 40 Minutes
High transportation cost burden / low transportation access	Commute to Work via Public Transportation (%)
High transportation cost burden / low transportation access	Commute to Work via Walk and Bus (%)
High unemployment and underemployment	Employed Residents which Earn Less than $1,250/Month
High unemployment and underemployment	% working population living below the poverty line
High unemployment and underemployment	Unemployment Rate
High unemployment and underemployment	STEM employment
Limited water and sanitation access and affordability	Safe Drinking Water Violations
Low income	Average Household Income
Low income	Median Household Income
Racial and ethnic segregation	Asian Population (%)
Racial and ethnic segregation	Black Population (%)
Racial and ethnic segregation	Latinx Population (%)
Racial and ethnic segregation	Racial Segregation Index

- BRIC Elevation Criteria can be addressed using the corresponding variables, which come from the American Community Survey, Bureau of Labor Statistics, EPA Air Pollutants, and U.S. Census

- This list represents a sample of what's available. Additional metrics may be of interest

Summary

- Physical climate risk to Municipal Bond securities can be modeled

- The latest scientific techniques and modeling approaches can be used and applied

- Development of concise, transparent metrics such as the risQ scores offer valuable options for managing financial impact

- Currently the impact from physical risks, is not priced in, but as climate change worsens, and defaults become more likely, these tools will become essential