Flood Risk and Housing Market Dynamics Across CONUS Coastal Communities

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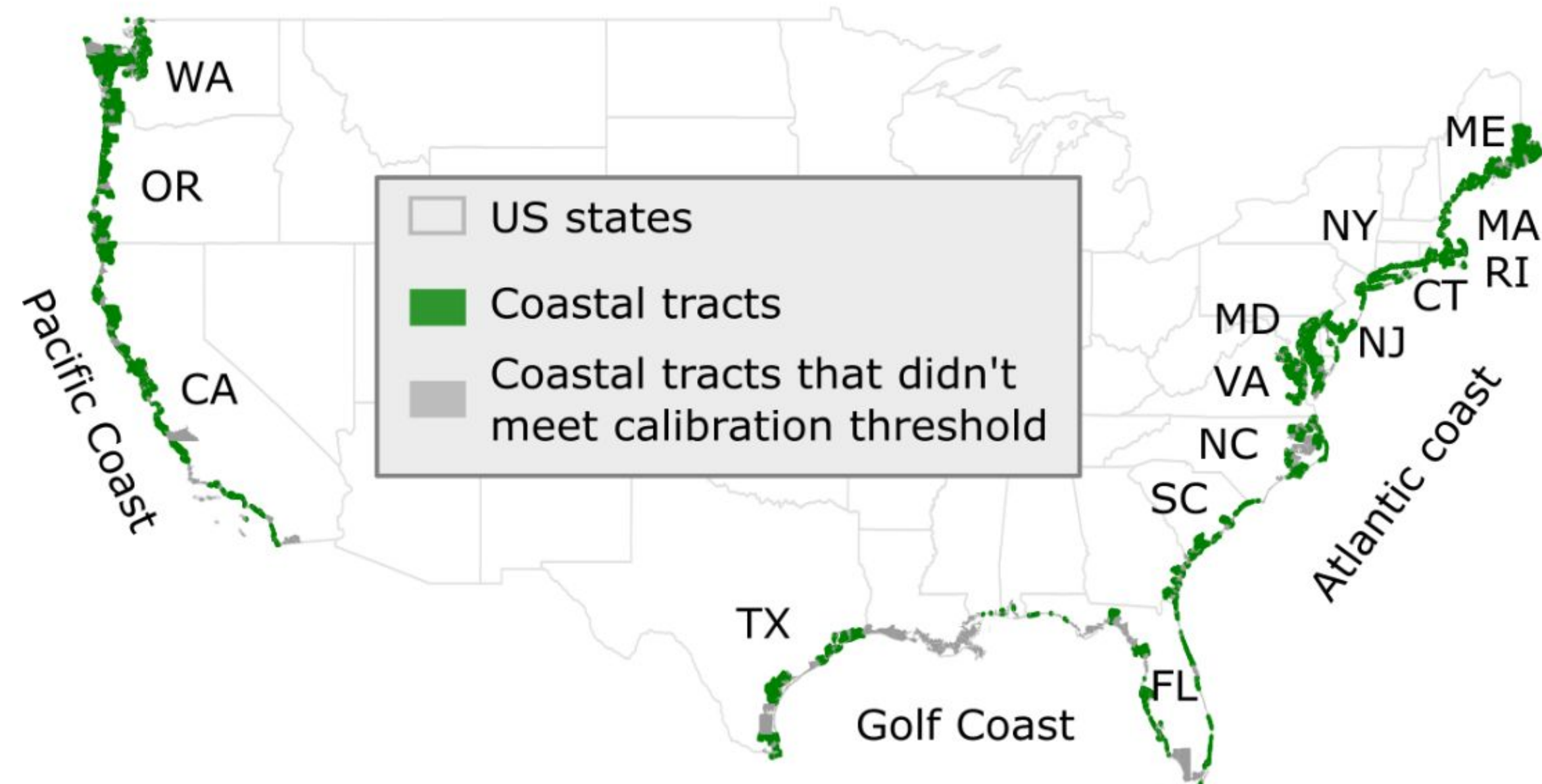1 Department of Natural Resources and the Environment, University of Connecticut, Storrs, CT, USA
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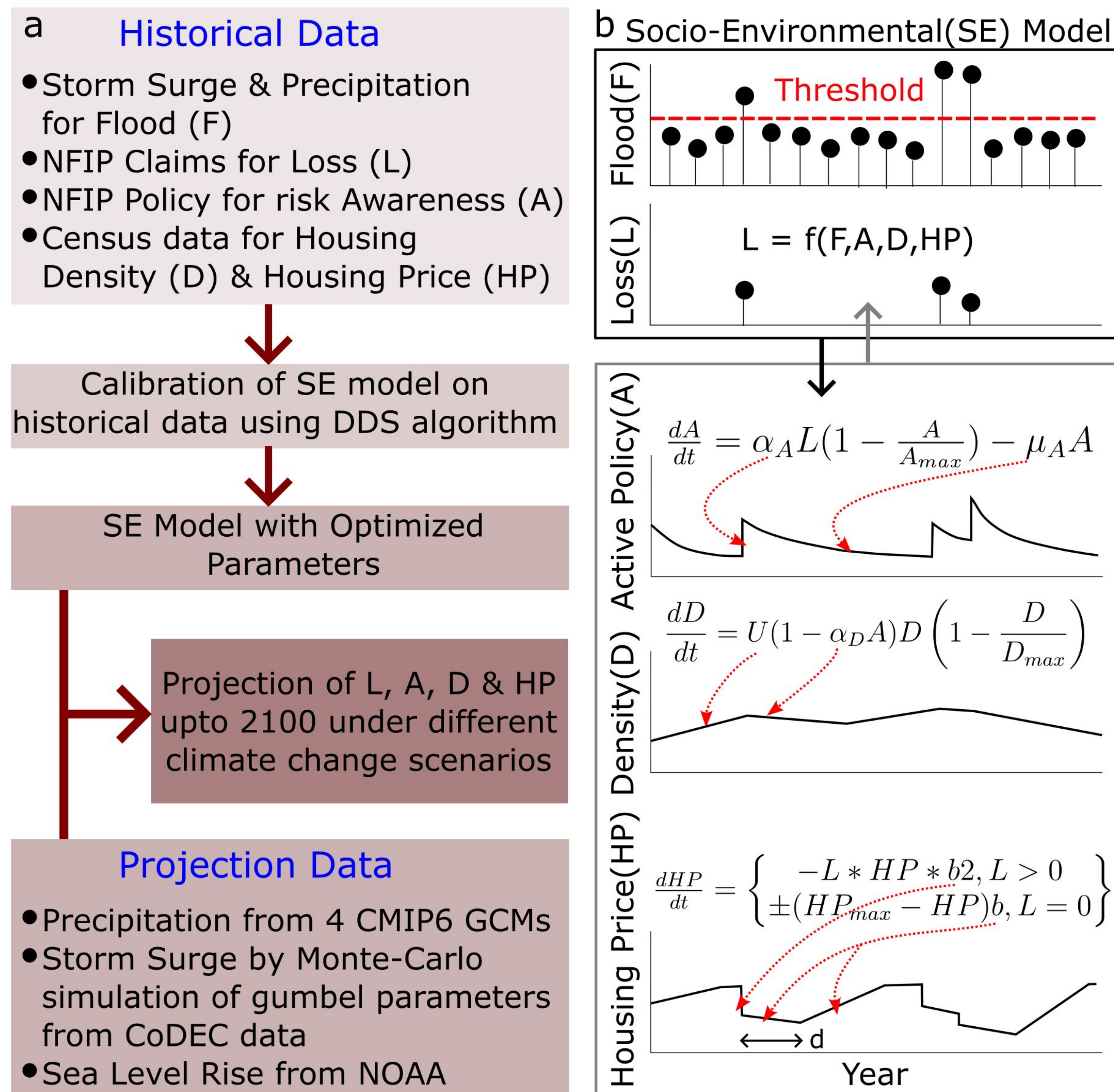
NATURAL RESOURCES AND THE ENVIRONMENT

1.Introduction

- Flood Risk = Hazard x Exposure x Vulnerability

- Human-flood systems are shaped by complex interactions between these risk components (e.g.,levee & adaptation effect), and this study explores:

  1 How human-flood system of CONUS coastal communities evolved (1970-2021)?

  2 How the system will respond to climate risks (2021-2100) under high (SSP585) and low (SSP245) climate change emission scenarios?

US states
Coastal tracts
Coastal tracts that didn't meet calibration threshold

WA, OR, CA — Pacific Coast
ME, NY, MA, RI, CT, NJ, MD, VA, NC, SC — Atlantic coast
TX, FL — Golf Coast

2.Methods

a   Historical Data
- Storm Surge & Precipitation for Flood (F)
- NFIP Claims for Loss (L)
- NFIP Policy for risk Awareness (A)
- Census data for Housing Density (D) & Housing Price (HP)

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Calibration of SE model on historical data using DDS algorithm

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SE Model with Optimized Parameters

→ Projection of L, A, D & HP upto 2100 under different climate change scenarios

Projection Data
- Precipitation from 4 CMIP6 GCMs
- Storm Surge by Monte-Carlo simulation of gumbel parameters from CoDEC data
- Sea Level Rise from NOAA

b   Socio-Environmental(SE) Model

Flood(F) — Threshold

Loss(L)

$$L = f(F,A,D,HP)$$

Active Policy(A)
$$\frac{dA}{dt} = \alpha_A L\left(1 - \frac{A}{A_{max}}\right) - \mu_A A$$

Density(D)
$$\frac{dD}{dt} = U(1 - \alpha_D A)D\left(1 - \frac{D}{D_{max}}\right)$$

Housing Price(HP)
$$\frac{dHP}{dt} = \begin{cases} -L * HP * b2, & L > 0 \\ \pm(HP_{max} - HP)b, & L = 0 \end{cases}$$

Year

- We calibrated SE models across CONUS Coastal tracts & used model parameters to explore historical human-flood dynamics across regions (Fig.1) and demographics (Fig.2)

- Next, we forecasted National Flood Insurance Program Loss and policy purchases to 2100 across coastal states (Fig.3) & different social vulnerability groups (Fig.4)

- Finally, we tested the effects of raising levees on mitigating forecasted flood risk by increasing existing surge threshold by +1, +2, & +∞m (Fig.5)

SE Model: Poudel, S., Caridad, C., Elliott, R., & Knighton, J. (2023). Housing market dynamics of the post-Sandy Hudson estuary, Long Island Sound, and New Jersey coastline are explained by NFIP participation. Environmental Research Letters, 18(9), 094009

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3.Results

- **Pacific:** Less flood-exposure, more sensitive National Flood Insurance Program (NFIP) participation & housing market
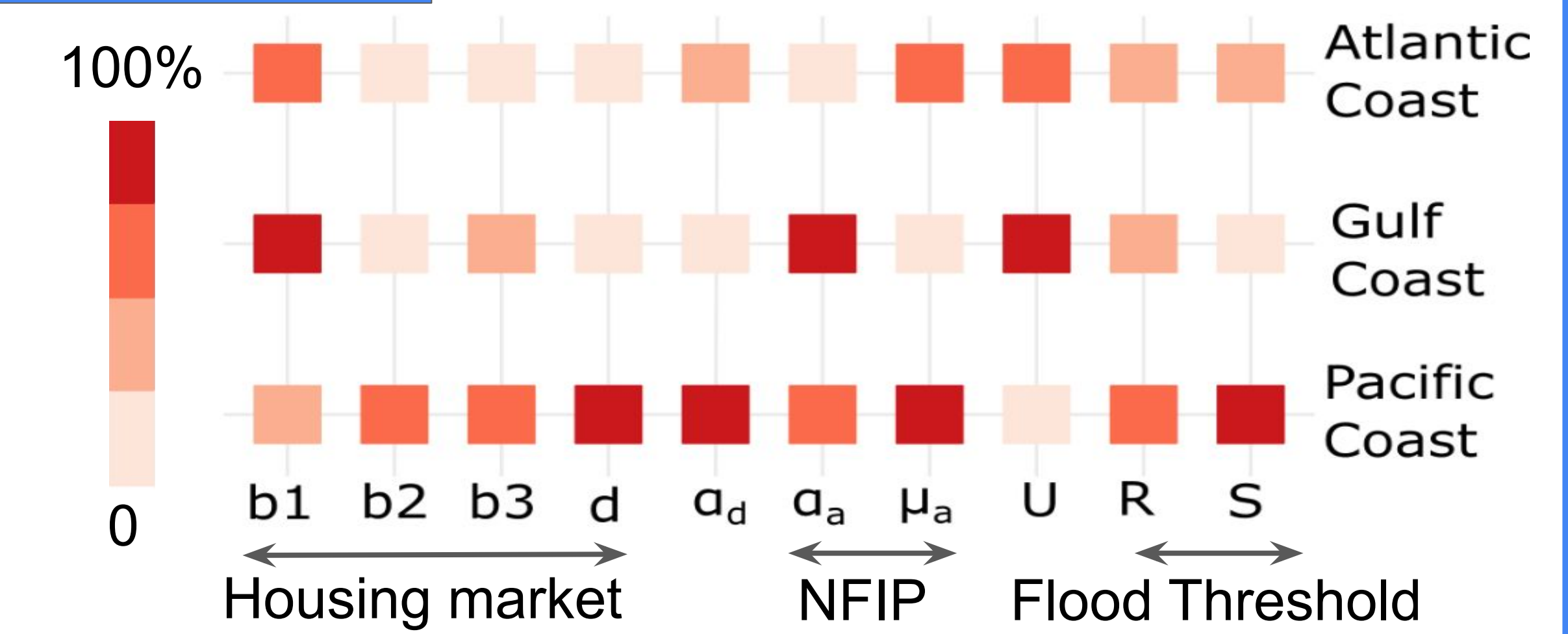- **Gulf & Atlantic:** More flood-exposure, less sensitive NFIP participation & housing market

Fig 1. Distribution of SE model parameters across CONUS coasts

More socially vulnerable communities showed lower insurance uptake post-flood followed by higher lapse rate and greater population change.
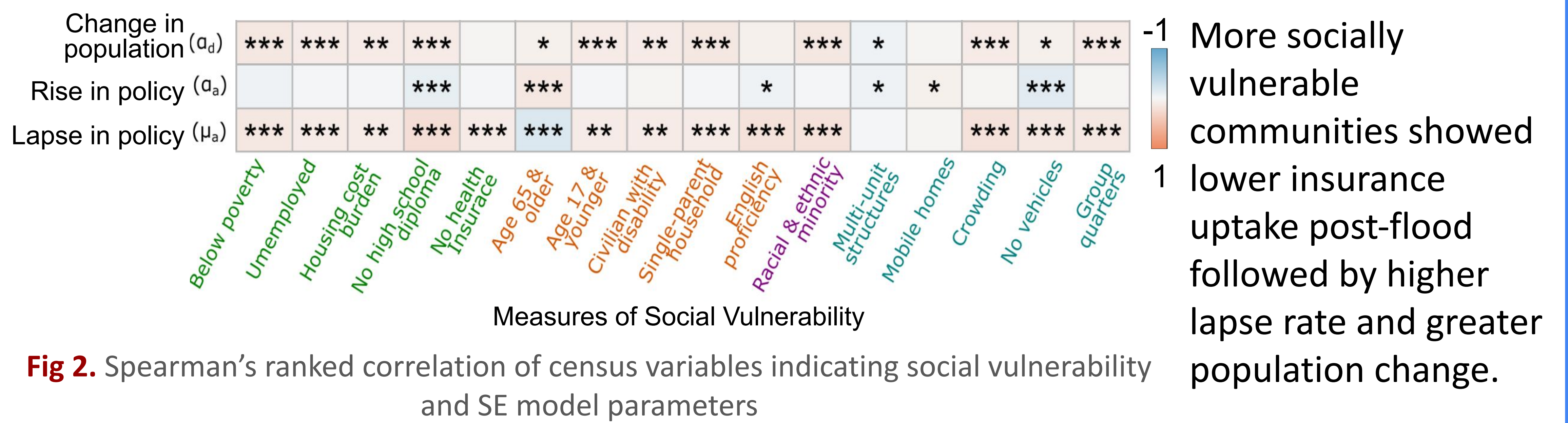
Fig 2. Spearman's ranked correlation of census variables indicating social vulnerability and SE model parameters

- Flood losses across CONUS coastal communities is forecasted increase between 25% (SSP245) & 130% (SSP585) above historical levels, with largest increases across Atlantic coast
- Number of properties covered by NFIP to increase from 10% during historical record to 13% (SSP245) & 16% (SSP585)
- The gap between loss claims paid by NFIP & uptake of insurance policies continue to widen
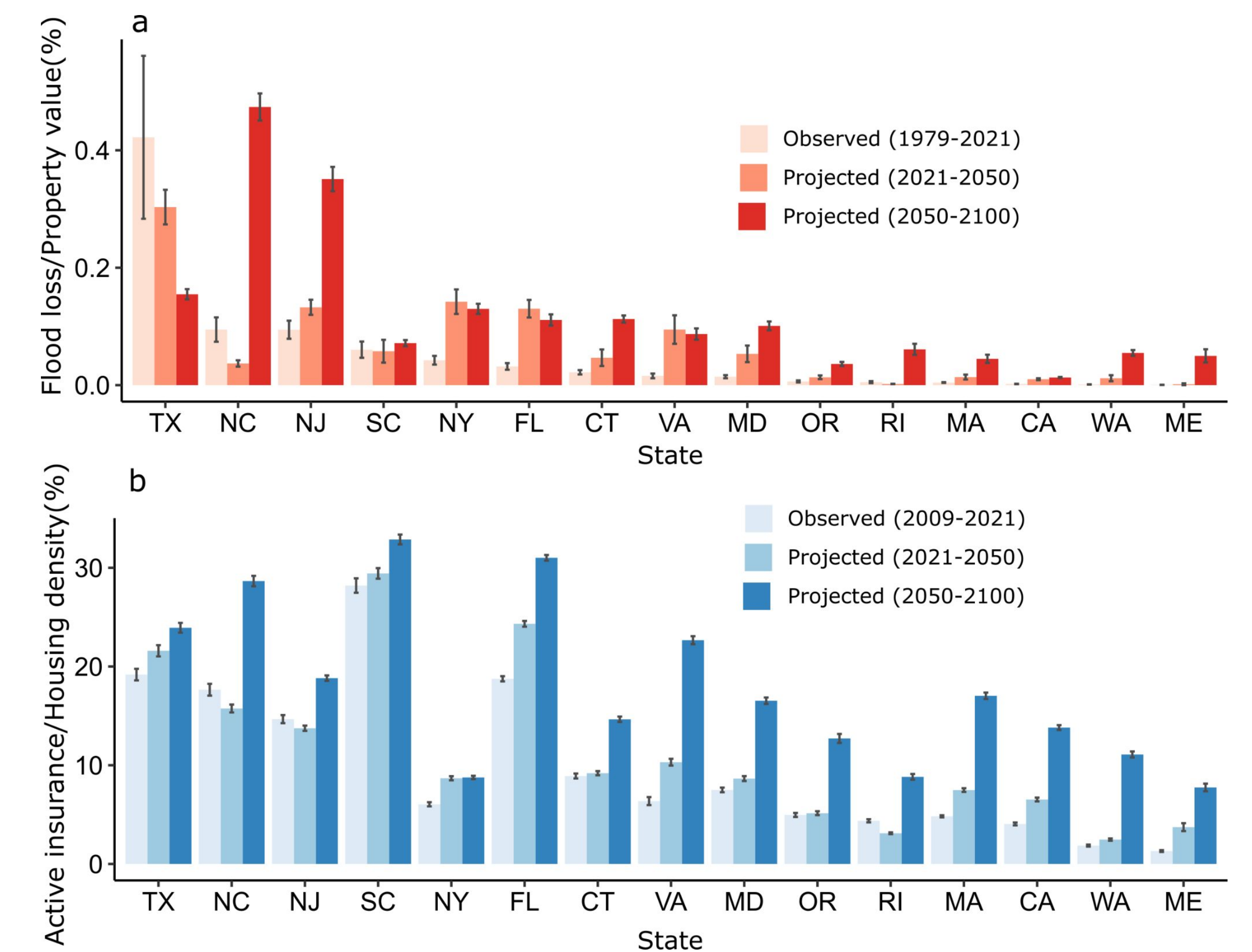
Fig 3. Average flood loss and insurance policy purchases for historical and forecasted period across coastal CONUS states (SSP585)
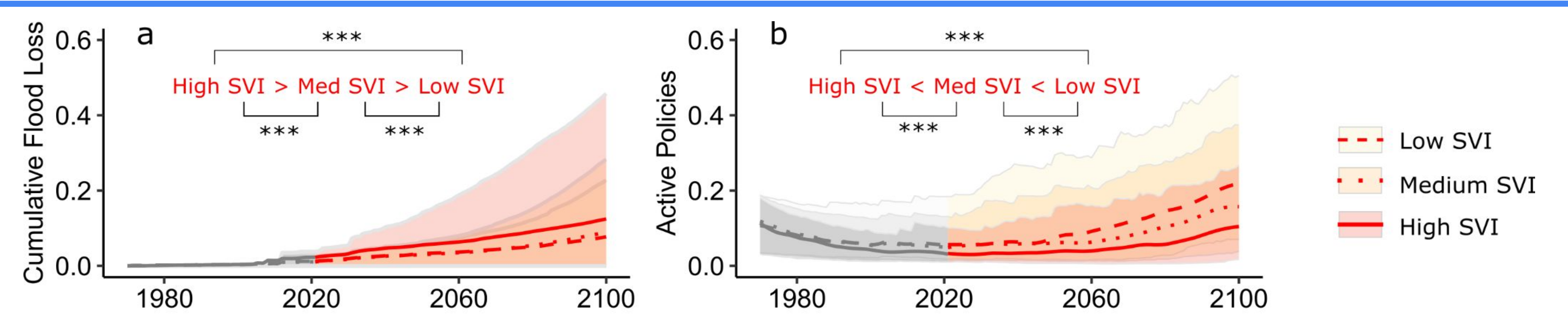
Fig 4. Historical and forecasted flood loss and insurance policy purchases among different social vulnerability groups across CONUS coastline (SSP585)

- Forecasted cumulative loss by 2100 for most socially vulnerable group is 55% higher
- NFIP policy purchases is predicted to grow at a slower rate for high social vulnerability group

- Raising levees by 1m can reduce some surge damage & negate sustained decline in home values
- Raising beyond 1m has limited benefit, as loss than are attributed to intense rainfall flooding events
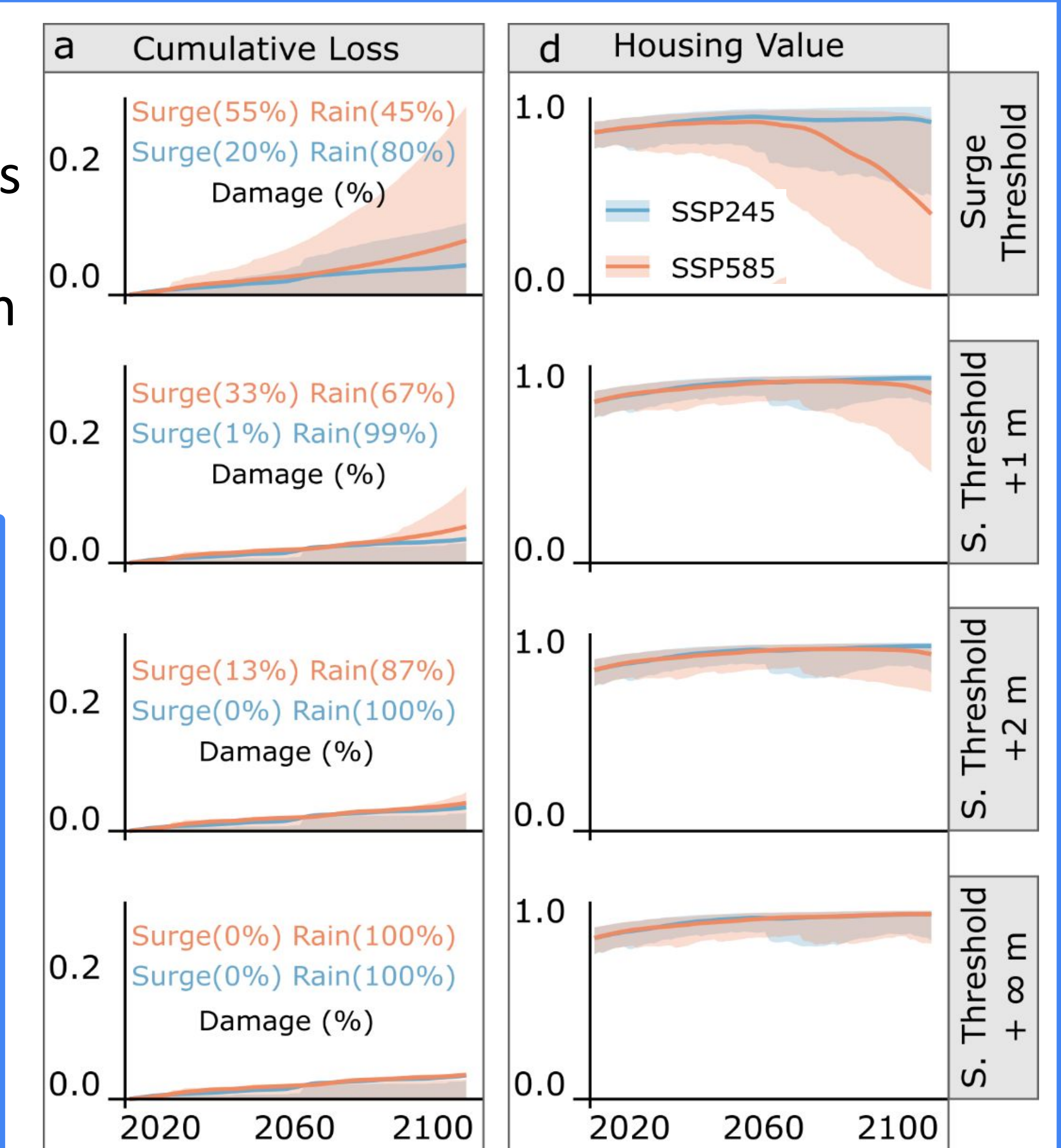
Fig 5. Flood loss and housing value for existing and increased surge threshold levels by +1,+2,+∞m

4.Conclusions

1 Strong regional and demographic variation in human-flood dynamics across CONUS

2 Rising flood loss with modest flood insurance purchases under climate change, with disproportionate impacts to socially vulnerable communities

3 Levees can reduce some catastrophic storm-surge losses & stabilize housing market but won't eliminate flood risks entirely