NC STATE UNIVERSITY

Coupling climate, land use, and sea level rise projections to identify threatened estuaries in North Carolina

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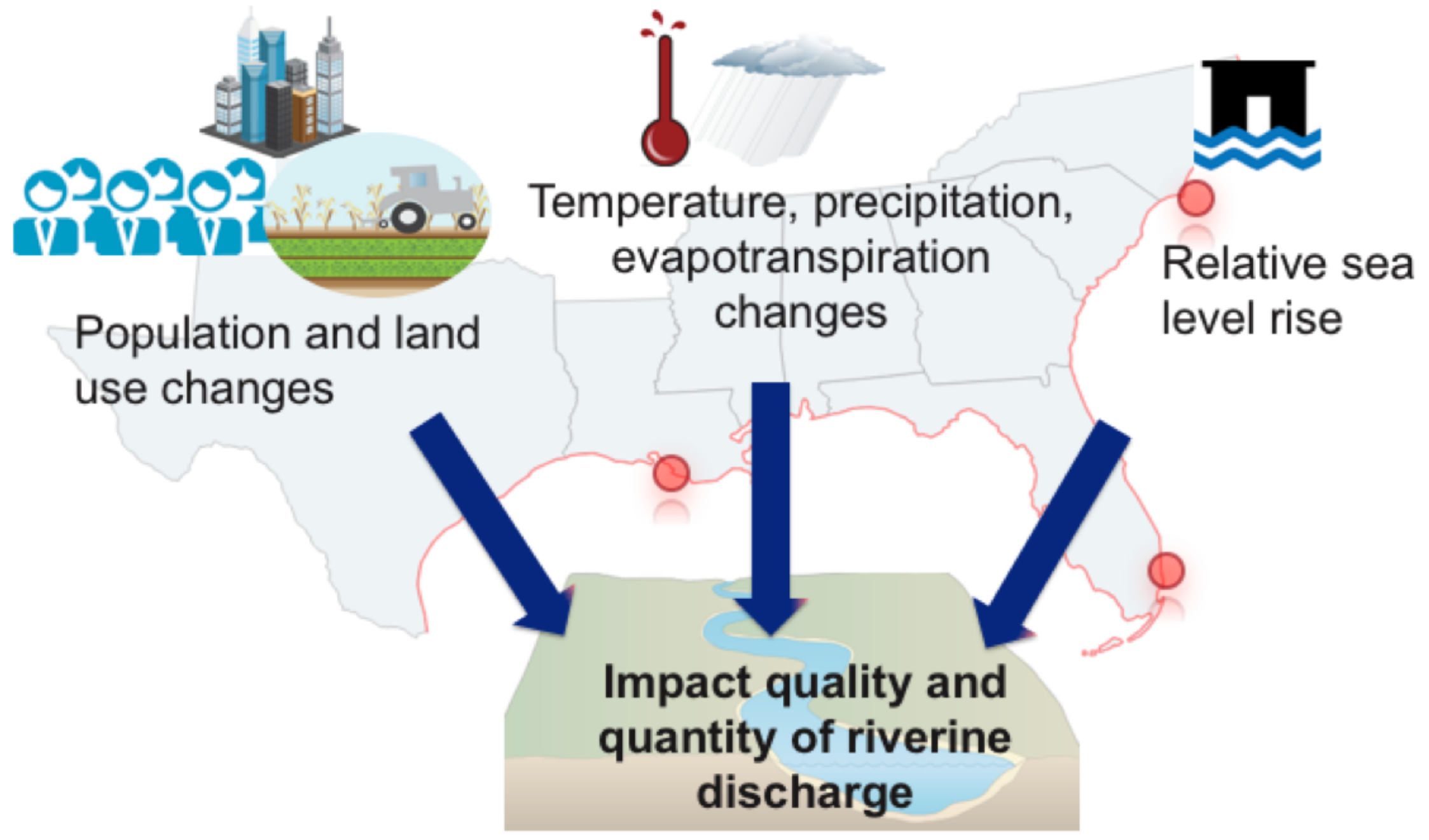
INTRODUCTION

- **Estuaries** are **environmentally**, **ecologically**, and **economically** systems. In the United States, 75% of commercial fisheries use estuaries during one or more stages of their life cycle**.**
- **Dramatic natural and anthropogenic changes** in the **South Atlantic** and the **Gulf of Mexico** are expected to impact estuarine ecology, thereby potentially impacting local economies that depend on estuaries to thrive.



- A quantitative **index** is needed to capture the different drivers that are expected to impact **vulnerability of estuarine systems and coastal communities**. Such an index would also allow for one-to-one comparisons of estuarine vulnerability to be made across locations.
- A vulnerability assessment is composed of the exposure, sensitivity, and adaptive capacity components.

Vulnerability = **Exposure** + Sensitivity - Adaptive capacity

- This index will incorporate both **marine and terrestrial drivers**. No prior studies have integrated **land-based drivers of coastal change** despite the fact that inland change has been shown to be more consequential to estuarine ecology than marine drivers in many areas.

OBJECTIVE

Quantify the exposure of estuaries in North Carolina as a function of projected terrestrial and marine change.

METHODS

Six basins (USGS HUC6) with outlets located along the **North Carolina** coastline were chosen for this specific study.

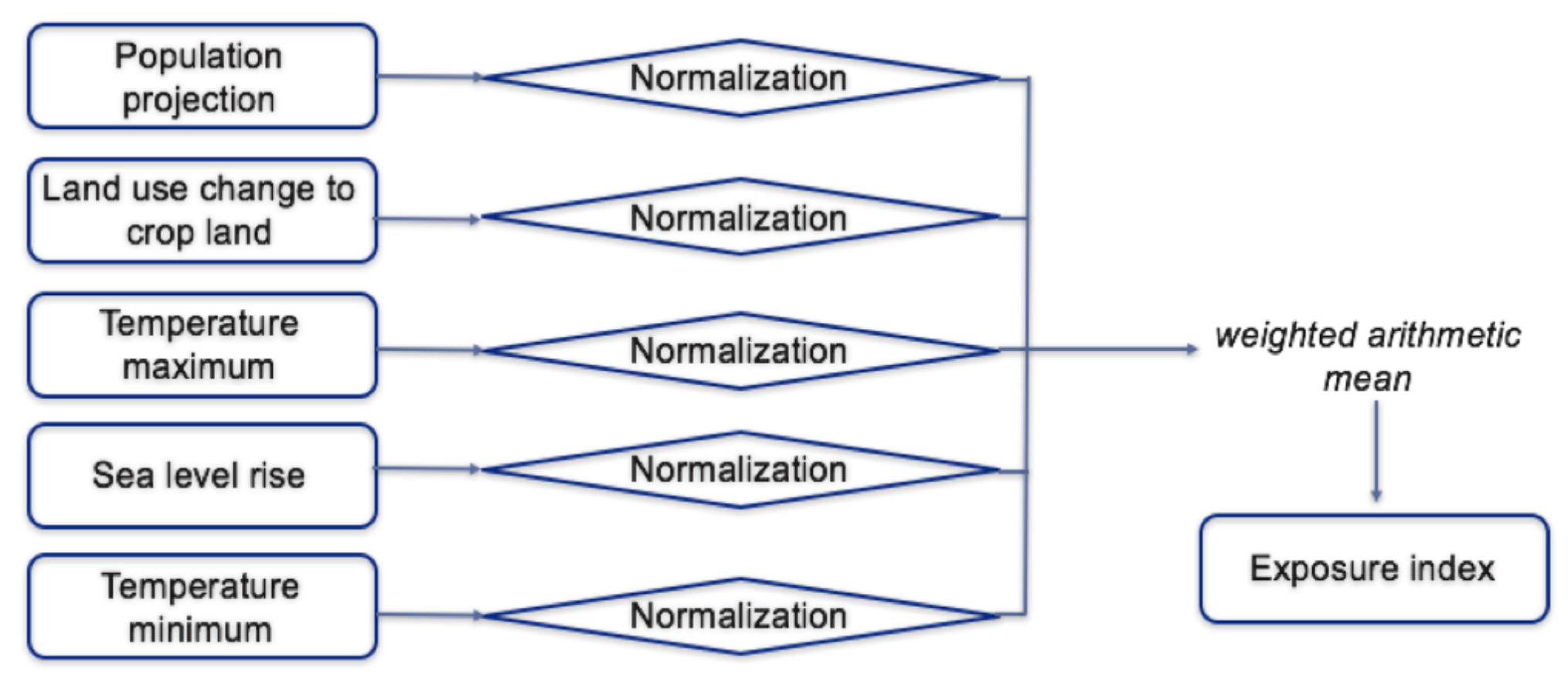
☐ Basins include in the study

■ North Carolina and Virginia Boundaries

Index framework

For **each coastal basin in North Carolina**, indicators were standardized to a continuous scale from **0 to 1**. Higher numbers represent higher exposure to an indicator.

Indicators chosen represent changes by 2050 under the Representative Concentration Pathways (RCP) 4.5. This scenario corresponds to intermediate future emissions.



Indicators

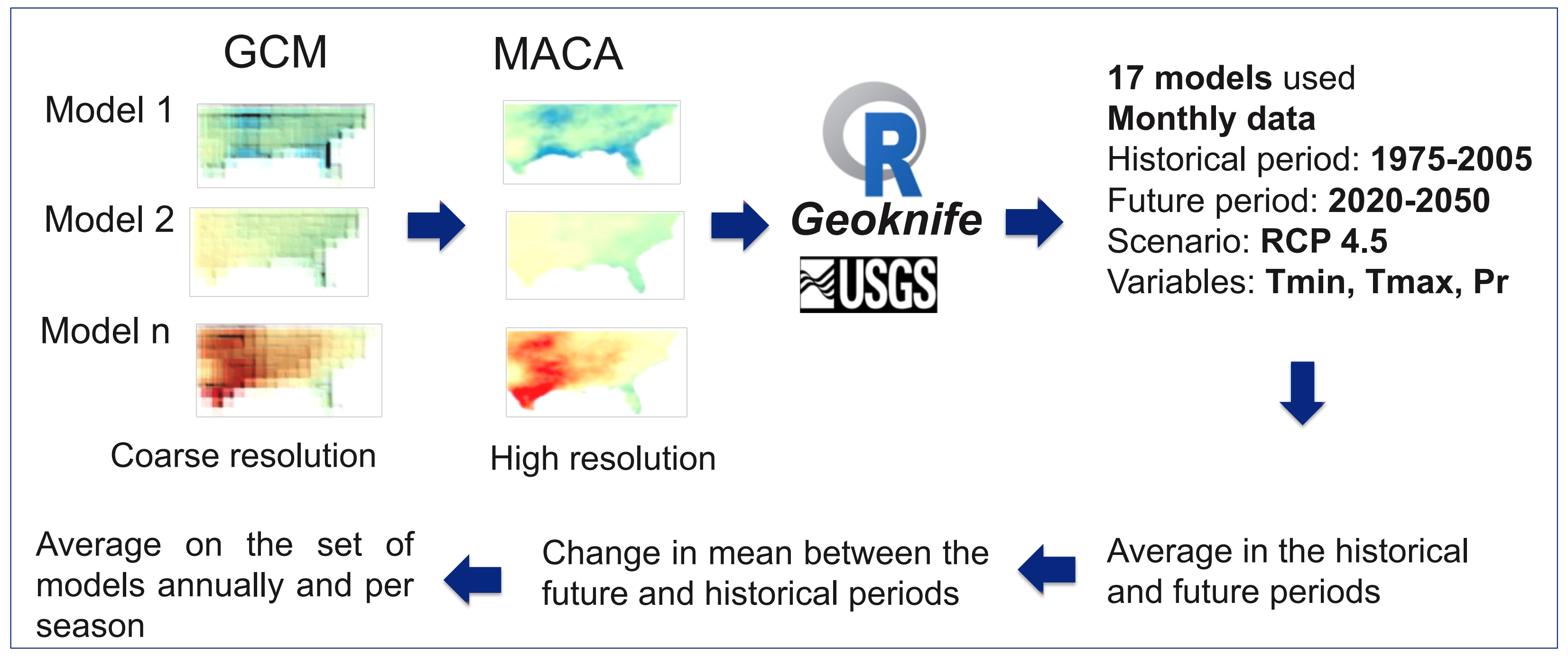
Linear regressions were used to standardize indicators. The table below presents the two bounds used for each indicator to build linear regressions.

Indicators	Value = 0	Value = 1
Temperature (minimum and maximum) change	Equal to 0°C	Greater than or equal to 2°C
Precipitation change	Equal to 0%	Greater than or equal to 20%
Relative sea level rise	Less than or equal to 0 mm/year	Greater than or equal to 7 mm/year
Land use conversion to cropland (probability greater than or equal to 0.50)	Area less than or equal to 0%	Area greater than or equal to 50%
Population density	Equal to 0 hab/km^2	Greater than or equal to 1,000 hab/km^2

Data compilation

➢ Climate change (2020-2050 vs. 1975-2005)

Tmin, Tmax, and precipitation were collected and pre-processed. Climatic data were obtained from **Multivariate Adaptive Constructed Analogs** (MACA) statistical downscaling method of climate data developed by the University of Idaho.

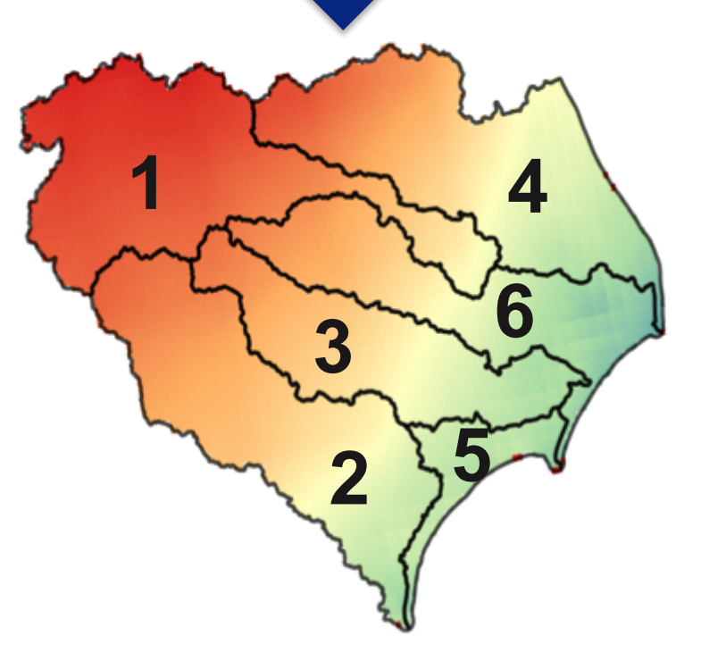


17 models used
Monthly data
Historical period: **1975-2005**
Future period: **2020-2050**
Scenario: **RCP 4.5**
Variables: **Tmin, Tmax, Pr**

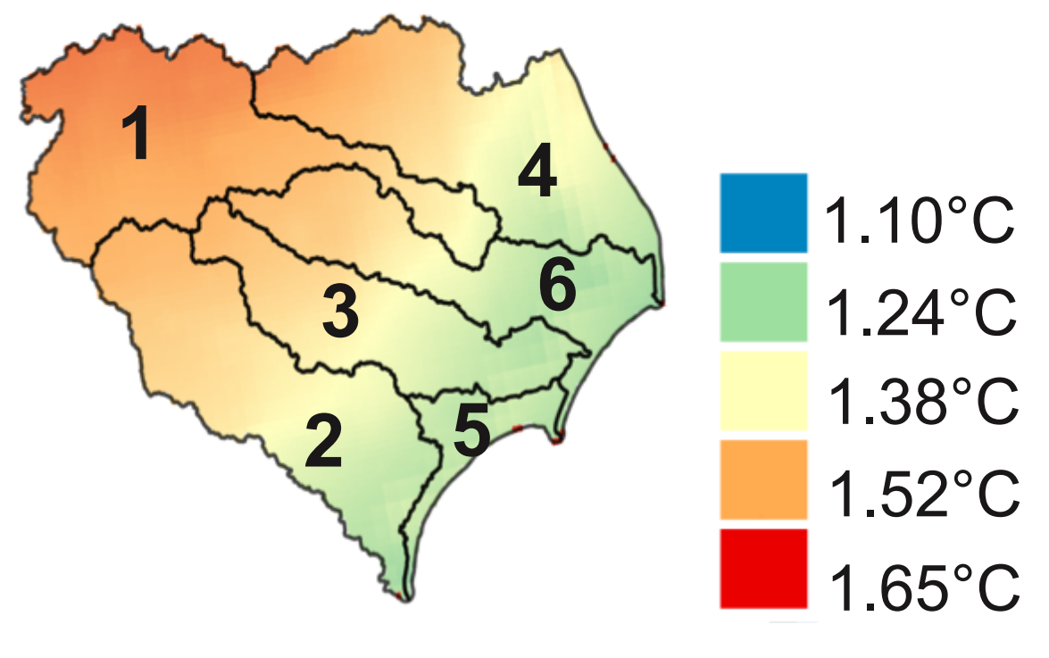
Average in the historical and future periods

Change in mean between the future and historical periods

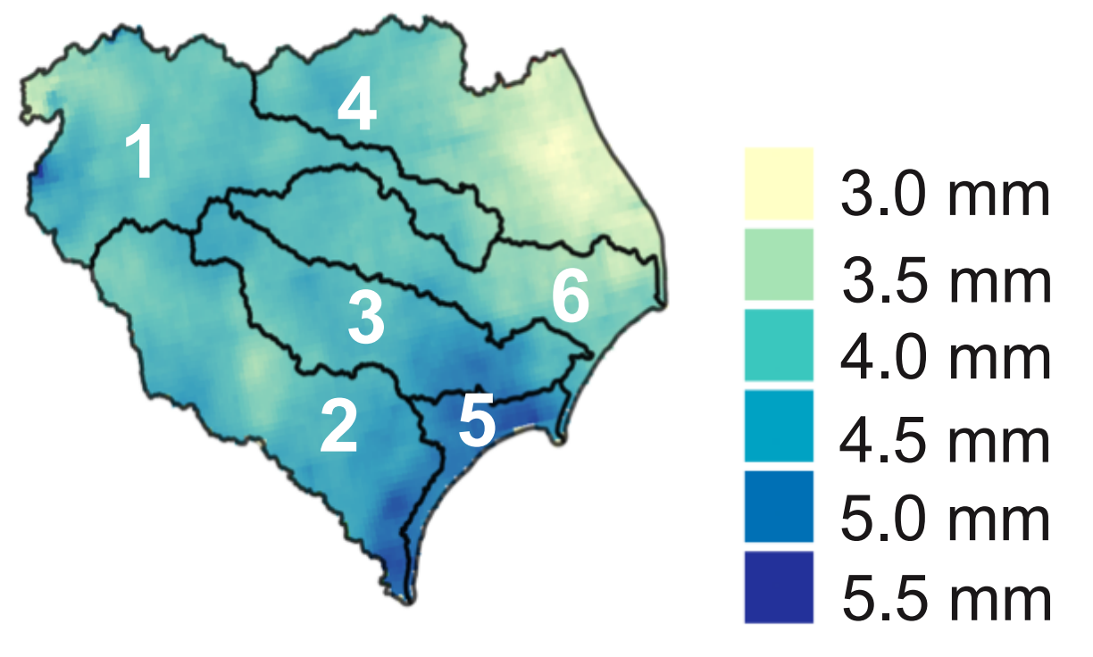
Average on the set of models annually and per season



Annual Temperature maximum change



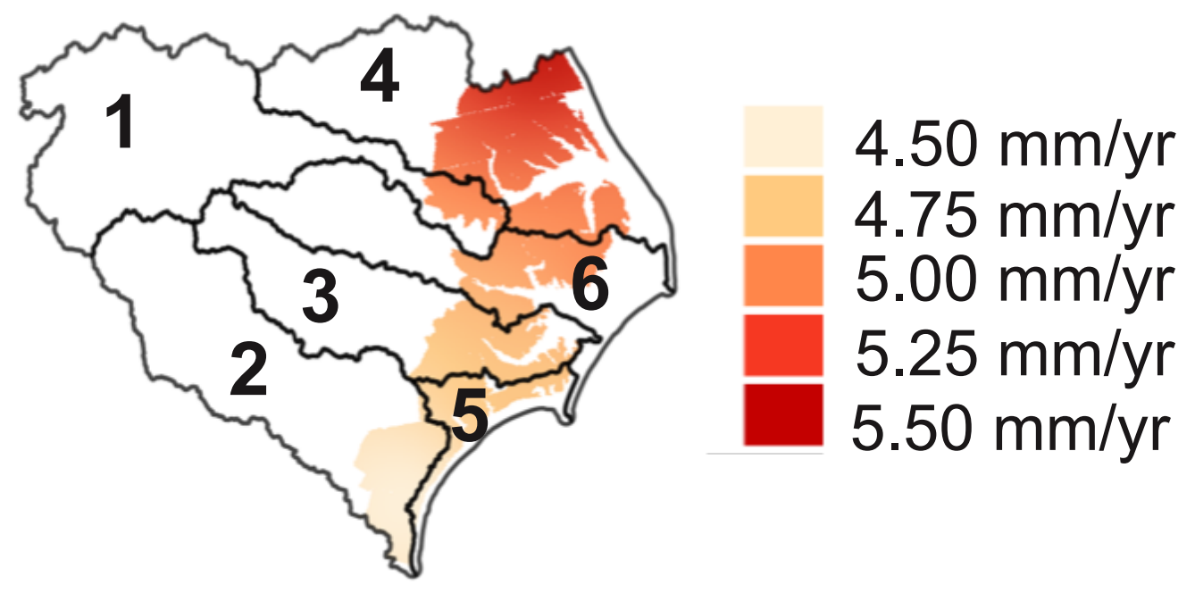
Annual Temperature minimum change



Annual Precipitation change

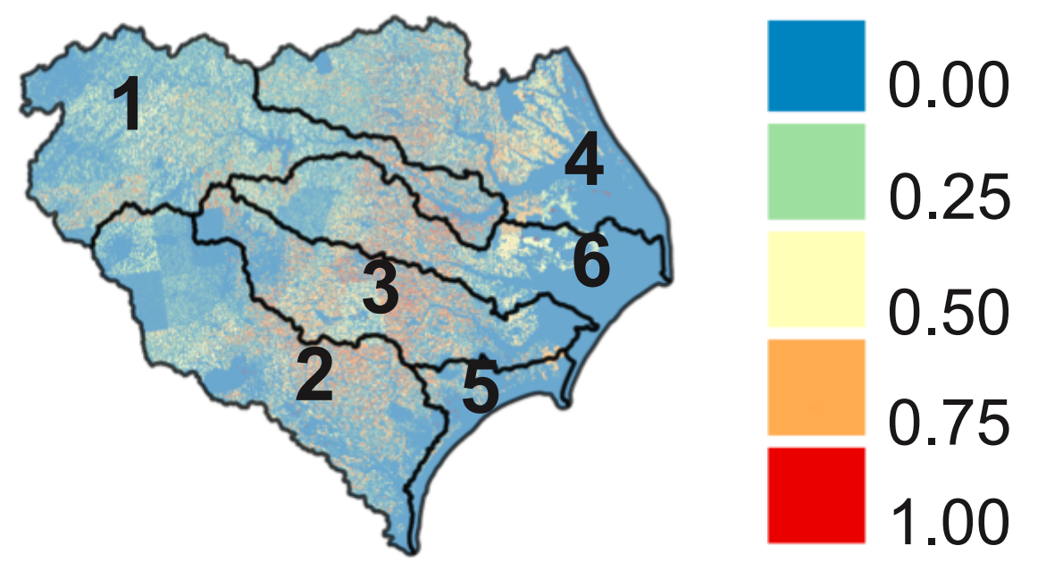
➢ Relative sea level rise (RSL)

Data were obtained from NOAA. The scenario selected was *intermediate* (close equivalent to RCP4.5). The projections align with NOAA sea level gauge stations (point data), and were interpolated with **Inverse Distance Weighting** and masked to **coastal county boundaries.**



RSL rate for 2000-2050

➢ Land use conversion to crop by 2050



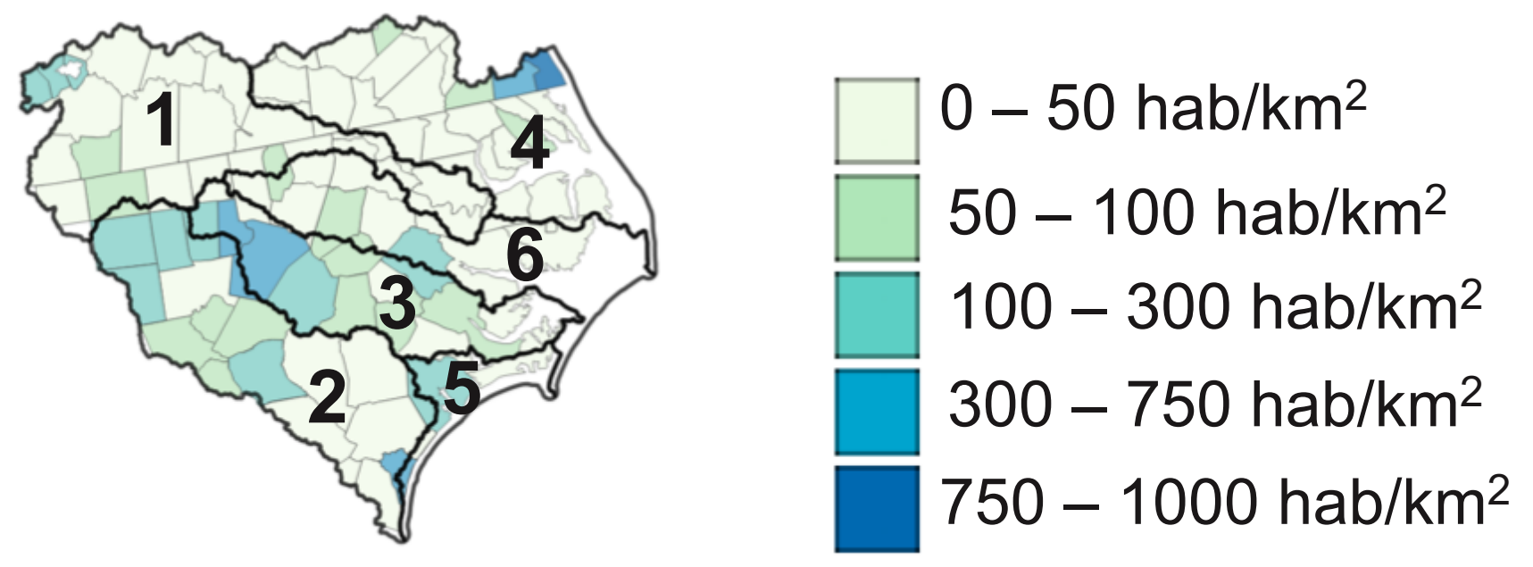
Probability of a land area converting to cropland by 2050

Land use change projections (2050) were prepared by the University of Wisconsin-Madison SILVIS Lab. The data corresponds to the "business-as-usual" scenario, which corresponds to greenhouse gas emissions approximately equivalent to RCP 4.5.

Data compilation

➢ Population density projection

County-level population projections were obtained from the EPA Integrated Land Use and Climate Scenarios program. The scenario B1 was selected (equivalent to RCP 4.5). County populations outside the basins were recalculated based on county areas inside the basins.



Population density projection in 2050

Basin score computing:

$$\text{Score}_{\text{basin}} = \sum_i score_i \times \frac{a_i}{A}$$

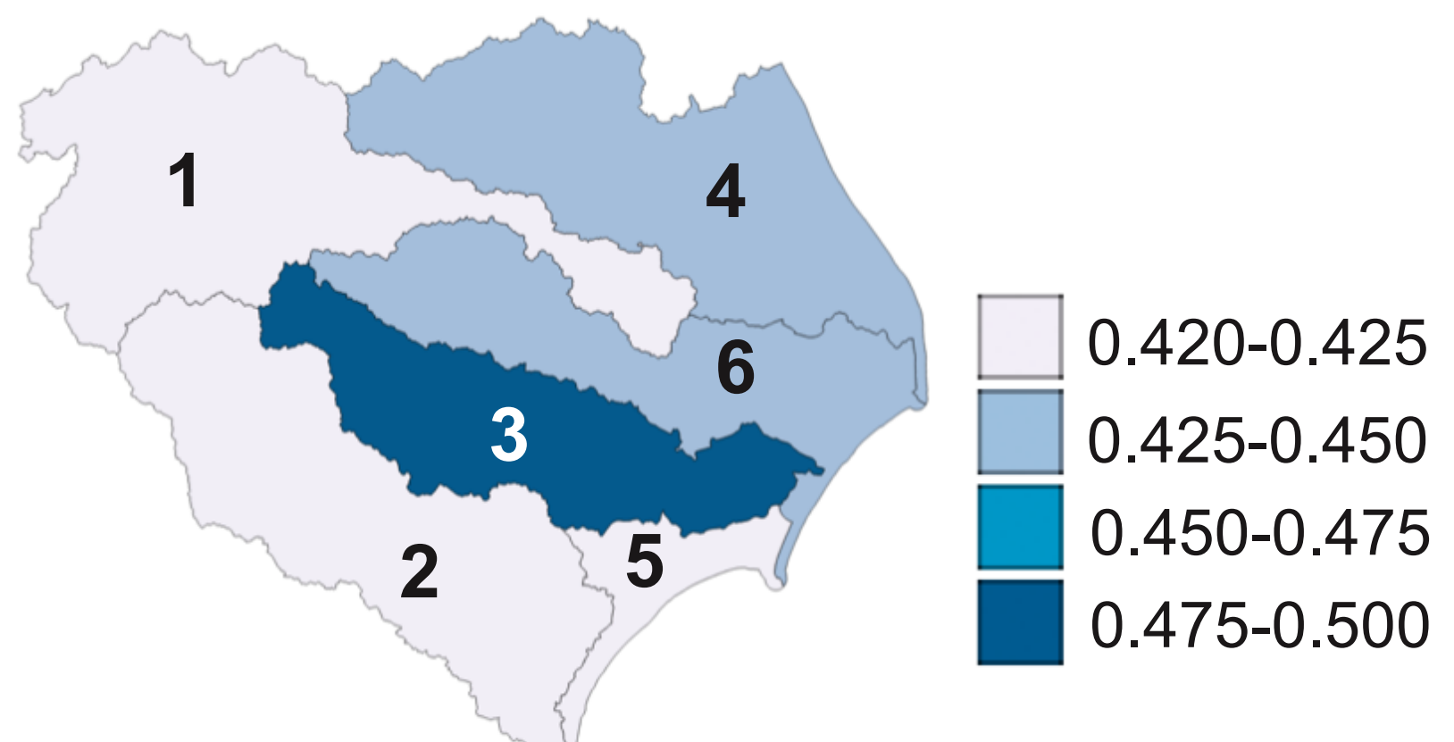
$score_i$: score of the county i
a_i: area of the county i
A : area of the basin

RESULTS: EXPOSURE OUTCOMES

The different scores of the basins obtained for each indicators are presented in the table below.

Indicators-2050	Roanoke (1)	Cape Fear (2)	Neuse (3)	Albemarle-Chowan (4)	Onslow Bay (5)	Pamlico (6)
Temperature maximum	0.671	0.611	0.611	0.586	0.604	0.586
Temperature minimum	0.663	0.613	0.624	0.612	0.610	0.612
Precipitation	0.203	0.199	0.199	0.168	0.224	0.180
Sea level rise	0.735	0.662	0.699	0.809	0.699	0.735
Land use change to crop	0.221	0.328	0.582	0.348	0.285	0.362
Population density	0.055	0.126	0.150	0.073	0.108	0.063

The final exposure score for each basin is presented in the figure below. Each indicator index was weighted with the same coefficient.



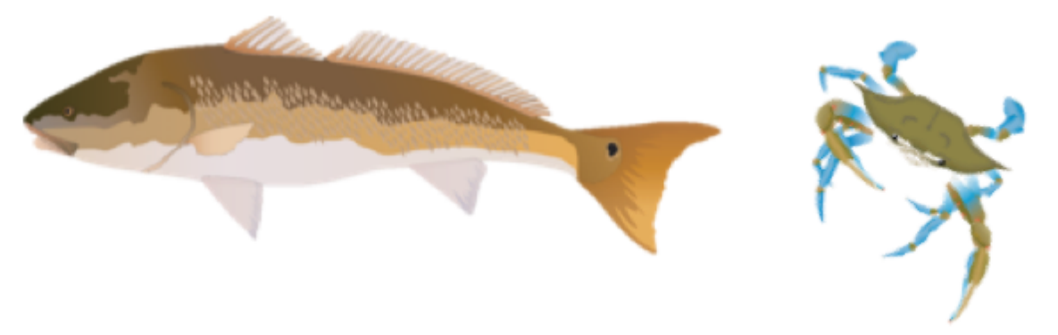
Final exposure index

Preliminary findings:
- Similar exposure scores
- Basins are highly exposed to relative sea level rise and temperature change
- Neuse basin is facing the greatest anthropogenic pressures and has the higher exposure score

FUTURE WORK

- Incorporate potential evapotranspiration in the exposure index.
- Expand study to include all coastal basins in along the U.S. South Atlantic and Gulf coasts, thereby allowing for regional trends to be inferred.
- Assess the vulnerability of estuarine fisheries and aquaculture operations to inland and marine change by merging the exposure index with **sensitivity** and **adaptive capacity** indicators:

SENSITIVITY



Estuarine-dependent species
Brackish aquaculture farming production
Diversity of estuarine-dependent landings

ADAPTIVE CAPACITY

Habitat quality:	**Human dimension:**
Diversity of benthic habitats	Access to scientific knowledge
River scores	Climate adaptation planning
Eutrophication	Economic revenue
	Presence of protected areas in estuarine basins