Integrated assessment of coastal flood modeling and community resilience in the Great Lakes

Photo - FOX17

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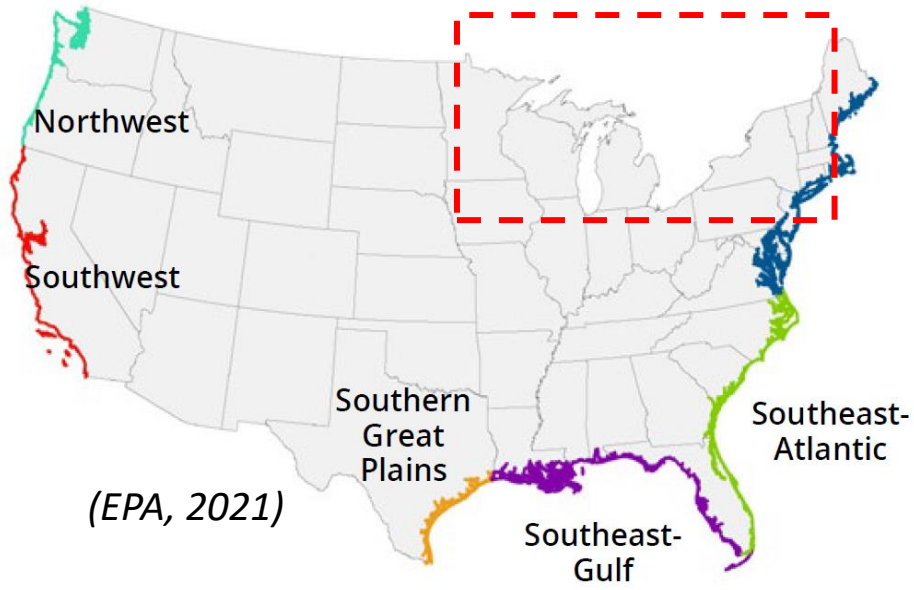
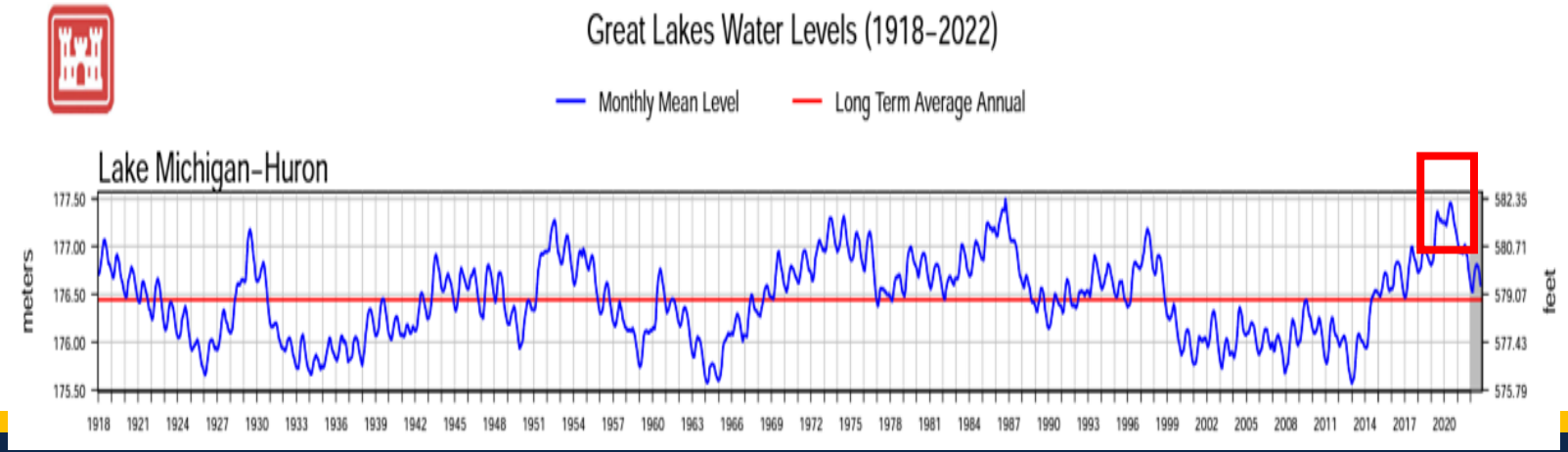
Background

- Trend towards increased lake level variability and uncertainty, more frequent storms.
- No generally accepted coastal flood models and predictions.
- Very few social vulnerability studies have focused on the Great Lakes Coasts.

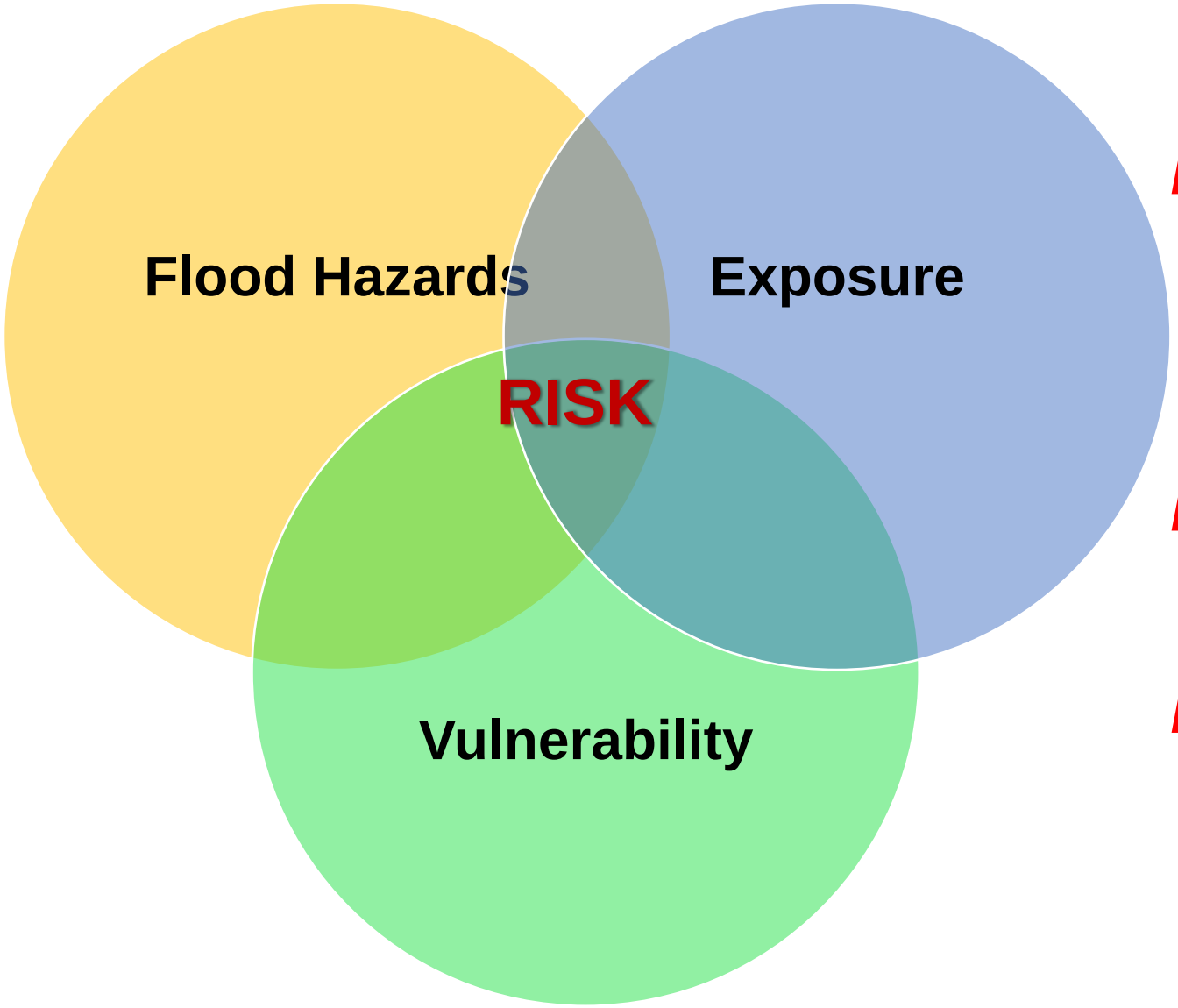


(EPA, 2021)



(e.g., Lake Michigan)

Flood Exposure and Social Vulnerability



I. ***Model development for coastal flood predictions, and performance assessment to select appropriate tools.***

II. ***Flood exposure at Census Tract Scale***

III. ***Unequal flood risks Vulnerability analysis for socially vulnerable populations***

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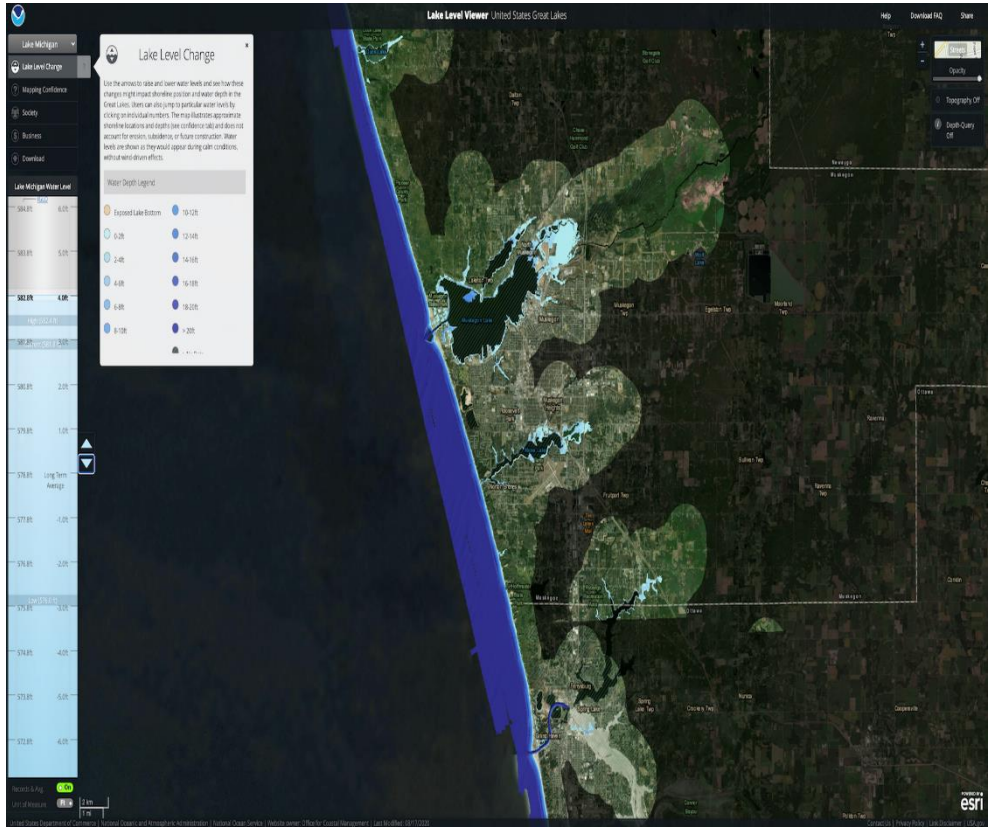
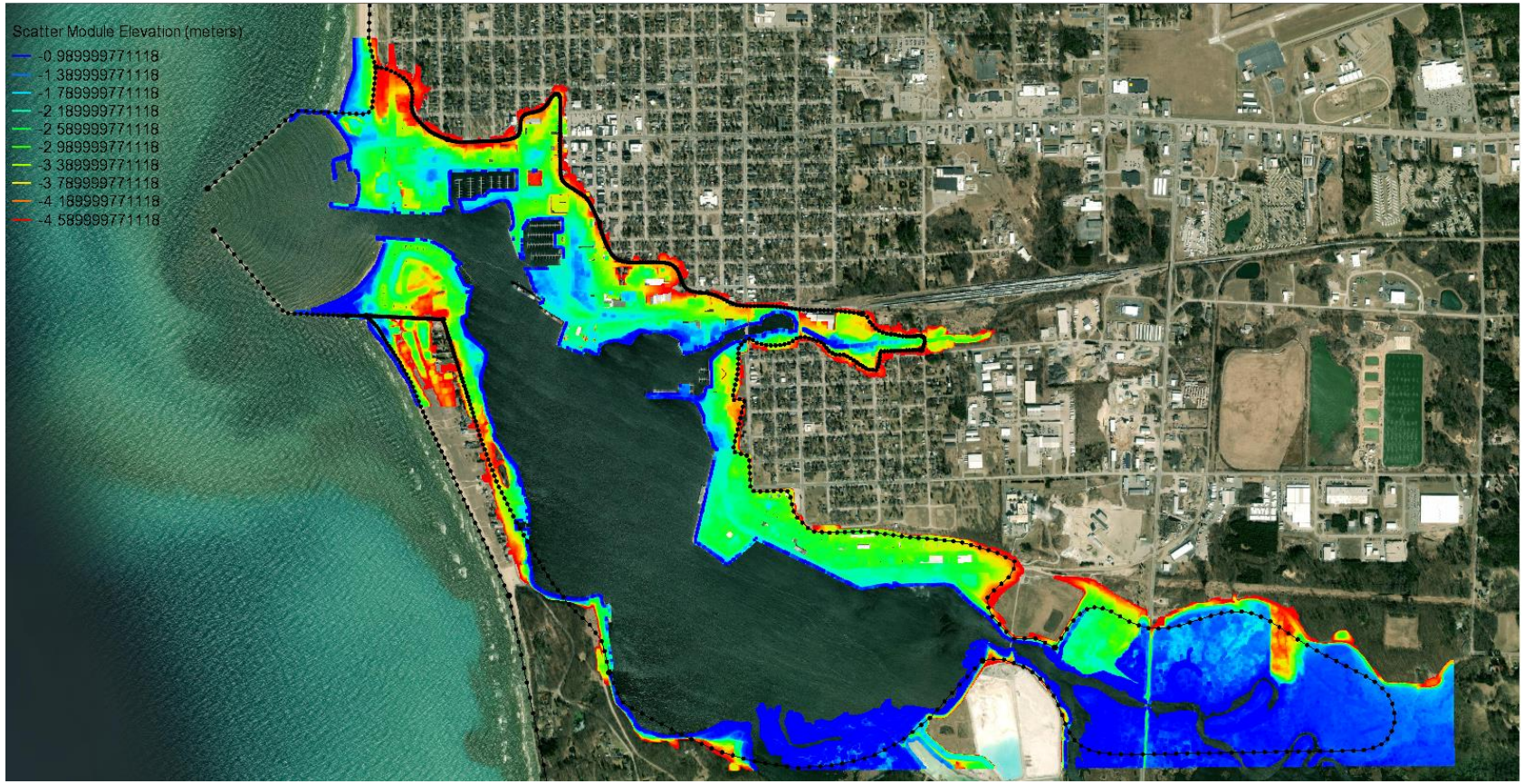
Gaps in NOAA's current Flood Prediction Tools

- GLOFS, uses Finite-volume Coastal Ocean Model (FVCOM)
- Grids of 200 – 2000 m resolution
- Mesh grids ends at shorelines



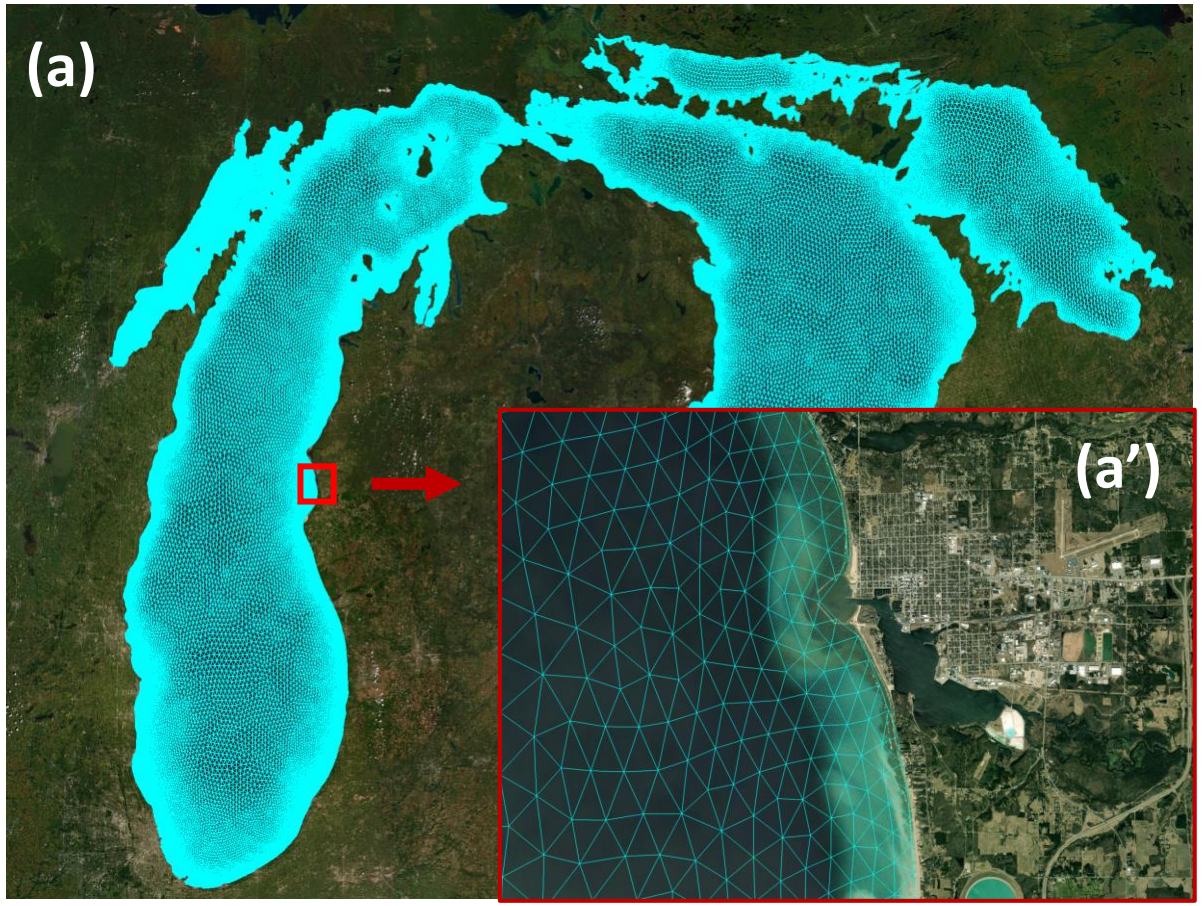
- A web-based tool creates visuals that capture lake level changes
- Range from -6 to +6 feet of historical long-term average water levels in the Great Lakes
- User defined value, no predictions

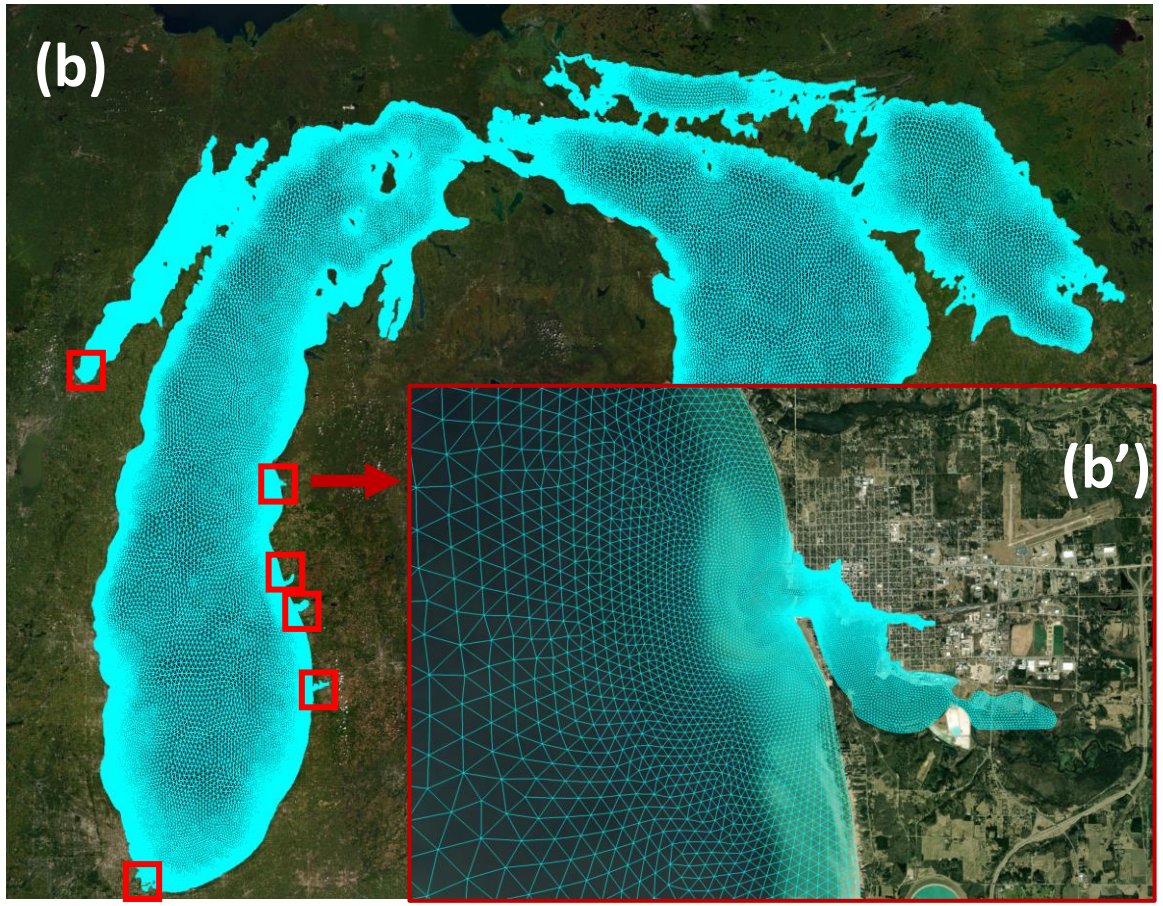
High-resolution data for grid configuration & flood simulations at census tract scales



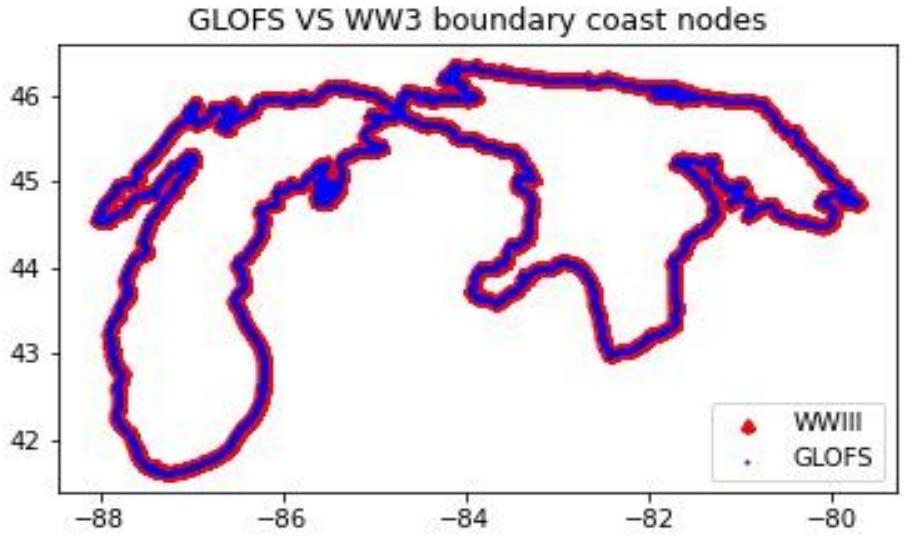
Example of high-resolution LIDAR data for Ludington river-mouth and flood-plain

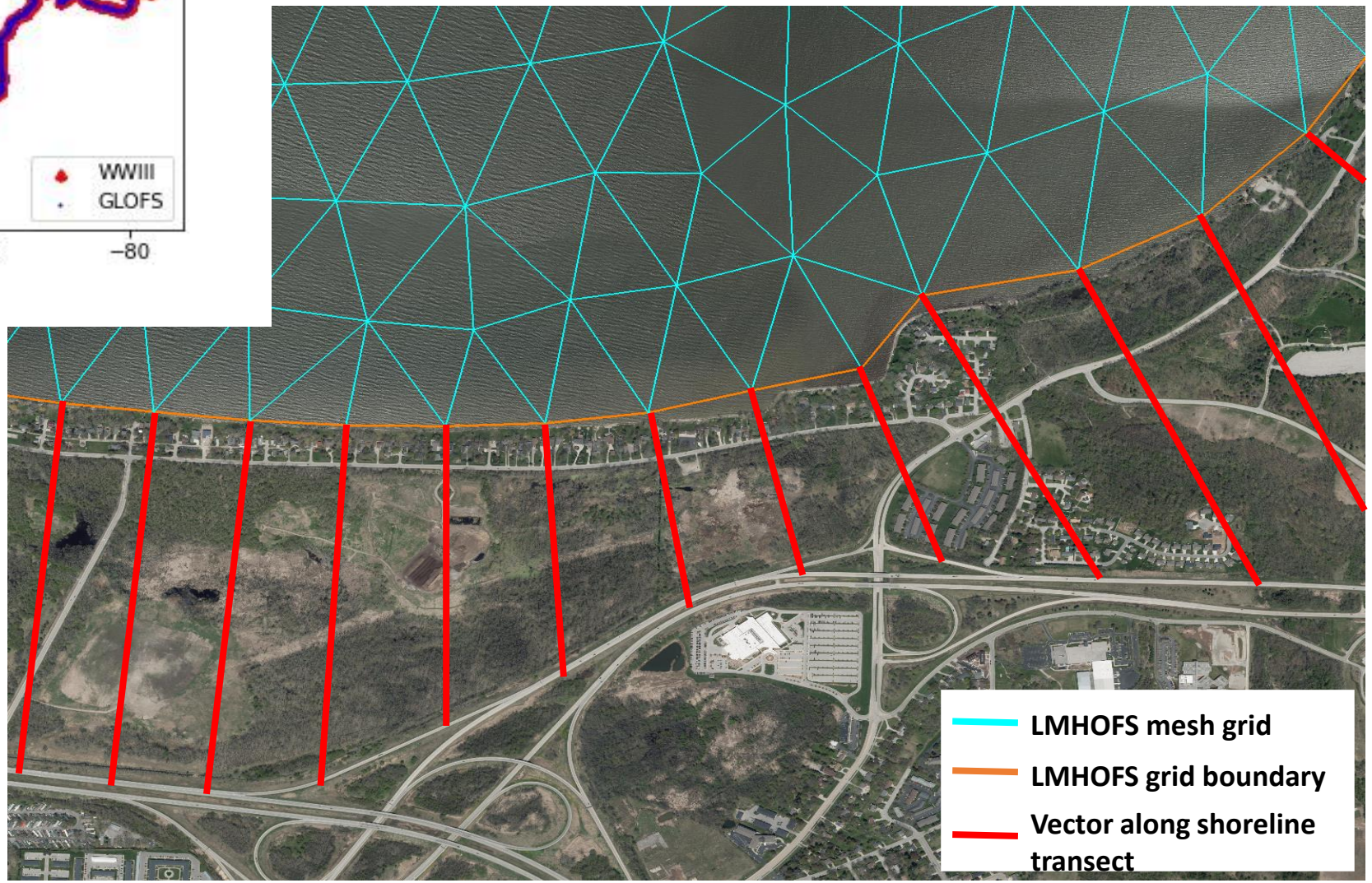
BTM & EXT





Total Water Level Approach





Coastal Flood Model Development & Evaluation

- Bathtub (BTM): GLOFS
  - Water-Level at shorelines directly compared with coastal land topographic elevation

- Total Water Level (TWL): GLOFS + WW-III Wave Run-up
  - Coupling GLOFS and WW-III for every coastal nodes
  - TWL = Water Level + Empirical Wave Run-up
  - Compare TWL with topographic elevation for coastal flooding

- Hydrodynamics (EXT): GLOFS + Extended Grids
  - Unstructured grids extended to river-mouth and coastal floodplains
  - Coastal flooding simulated using a 3D dry/wet treatment approach in FVCOM

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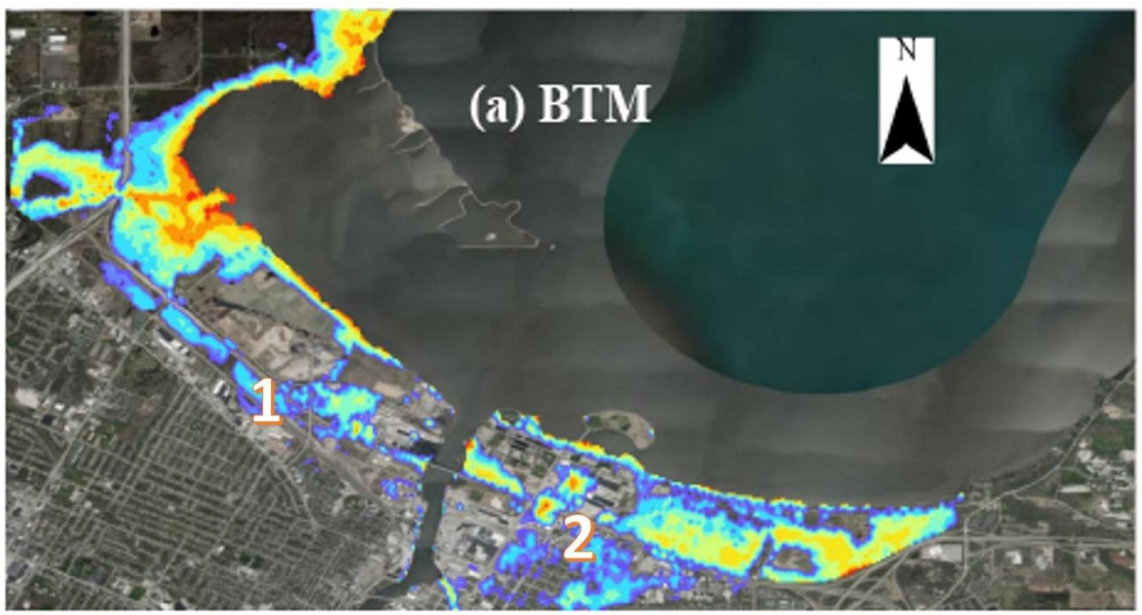
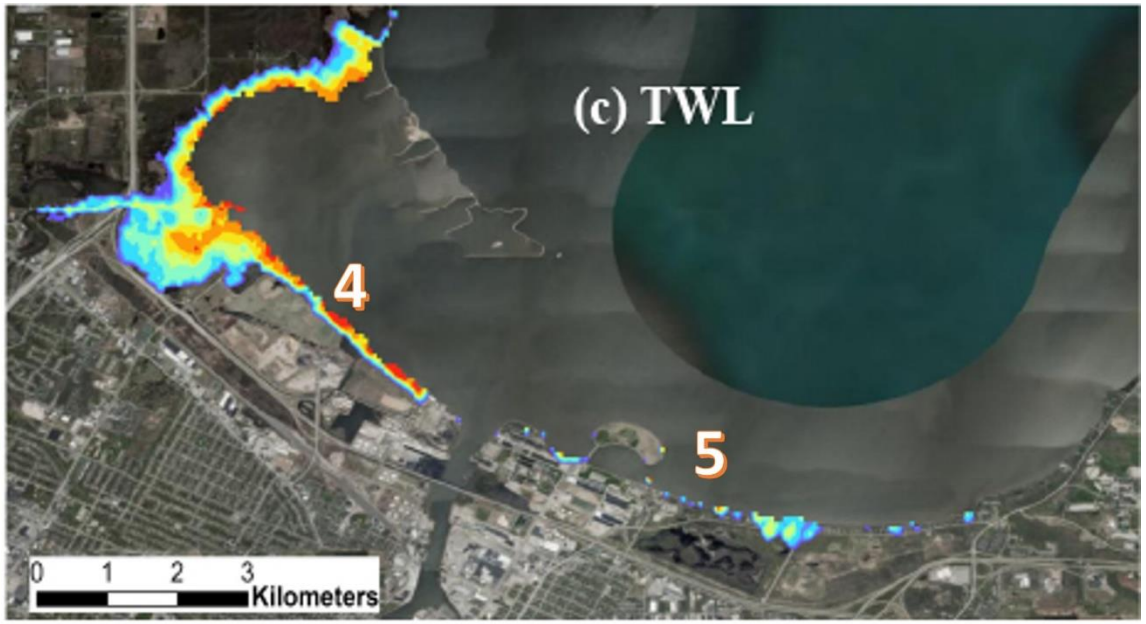
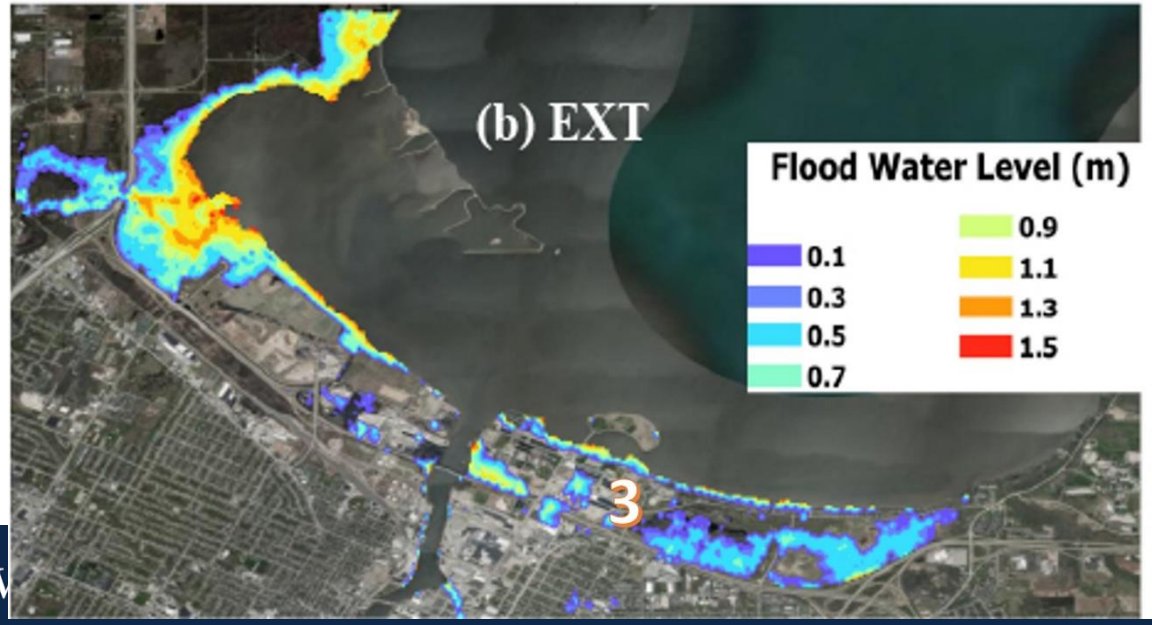
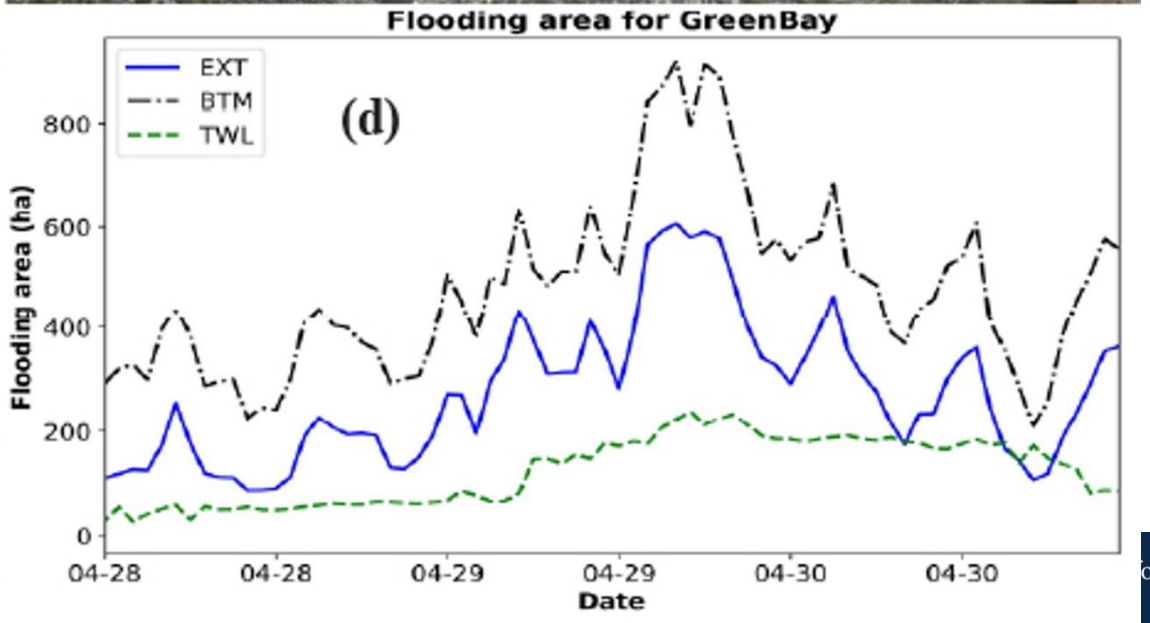
Model Intercomparison

(GreenBay – WI, 04/29/2020)



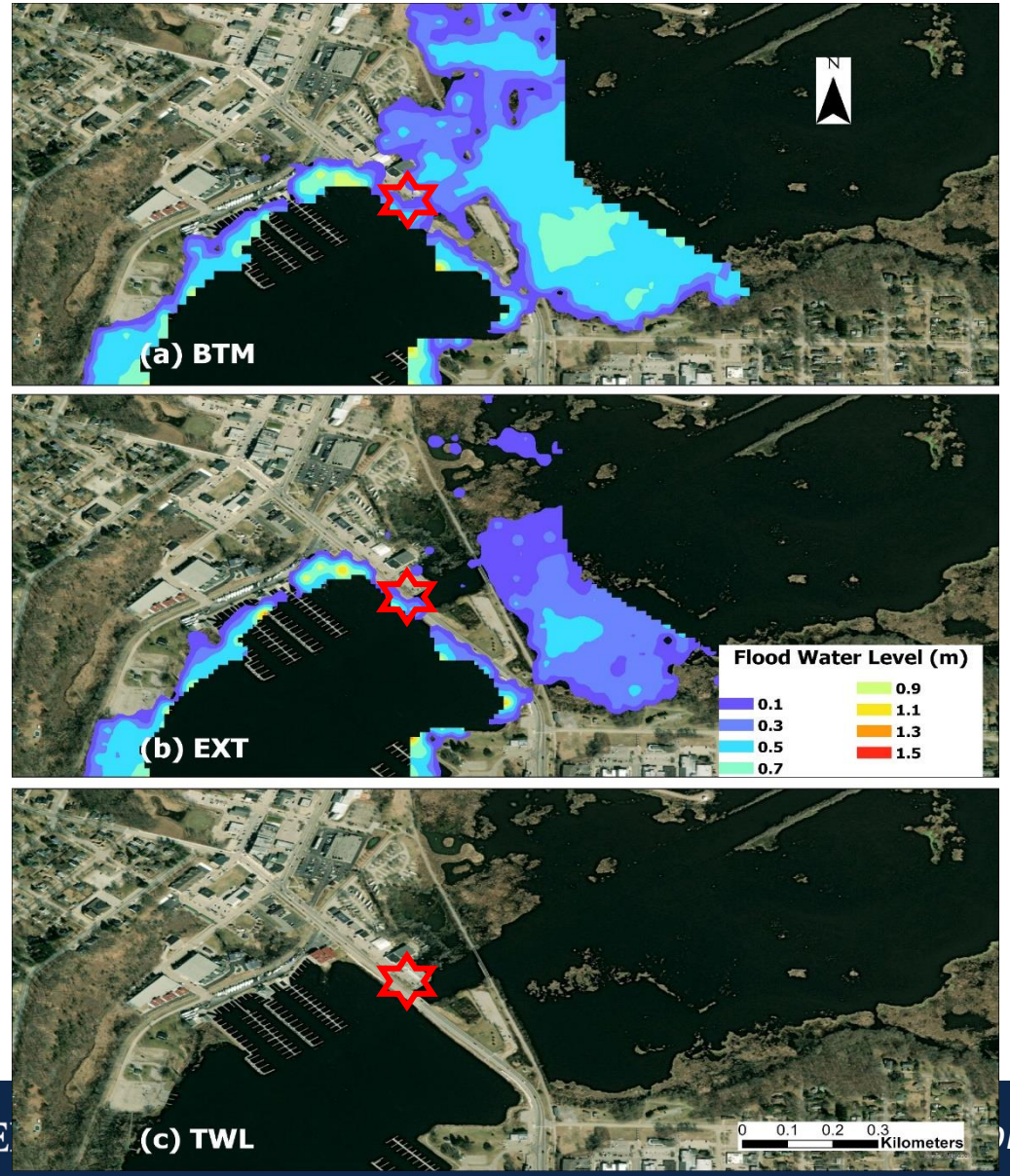


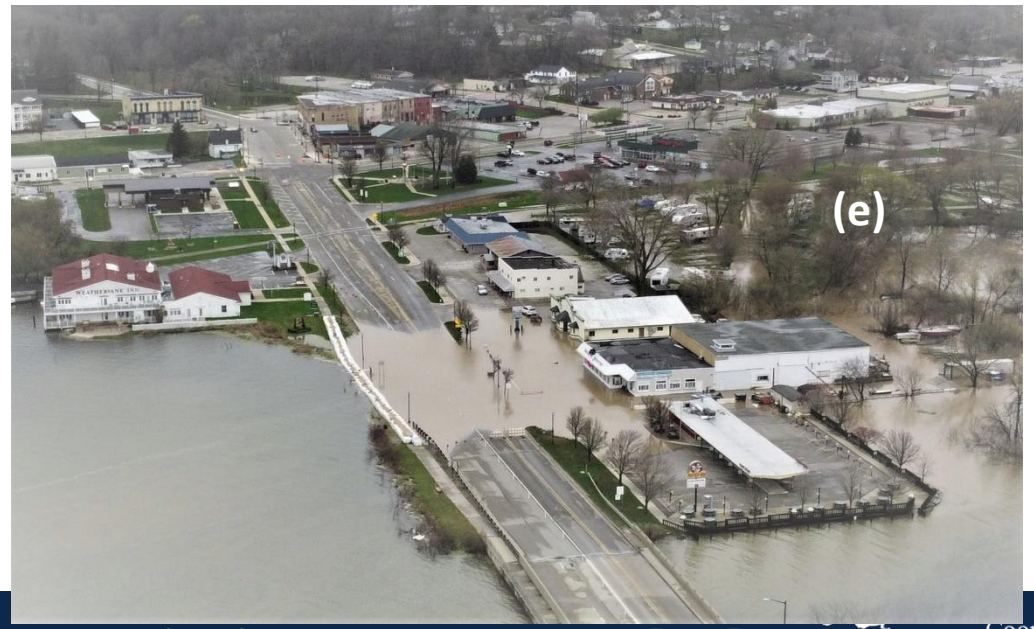




Model Verification Against Media Information

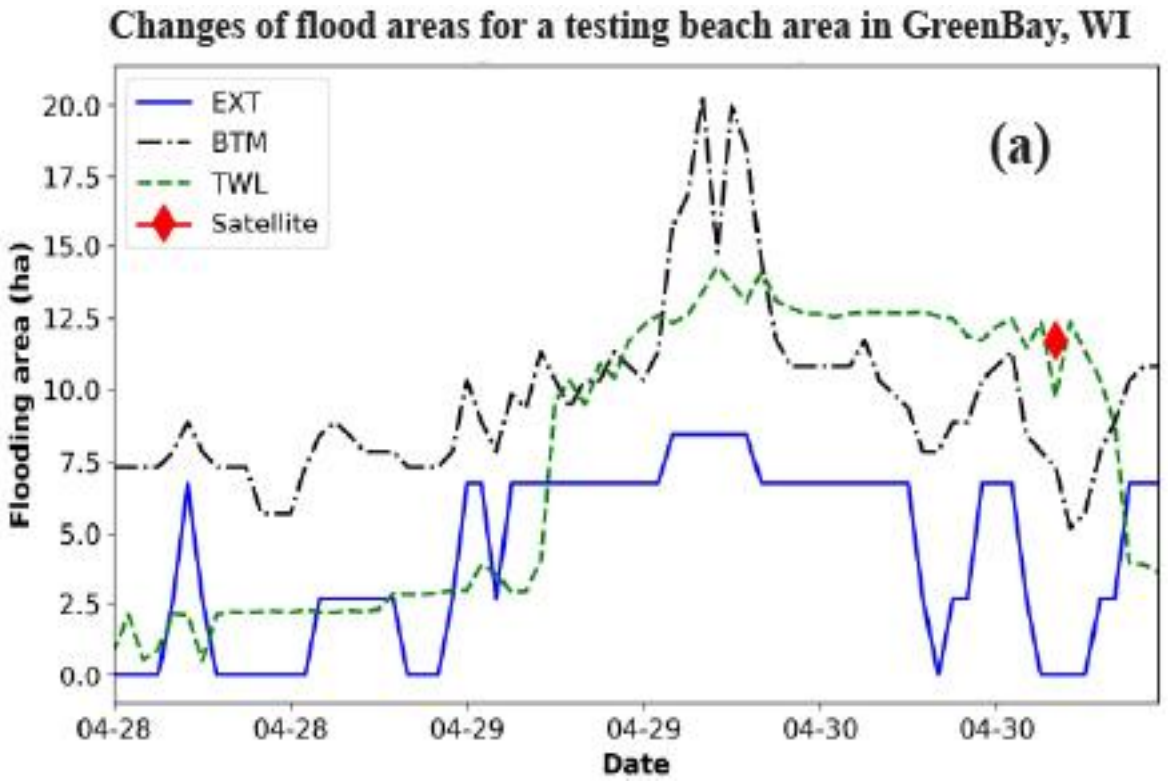
(Montague – MI, 04/29/2020)

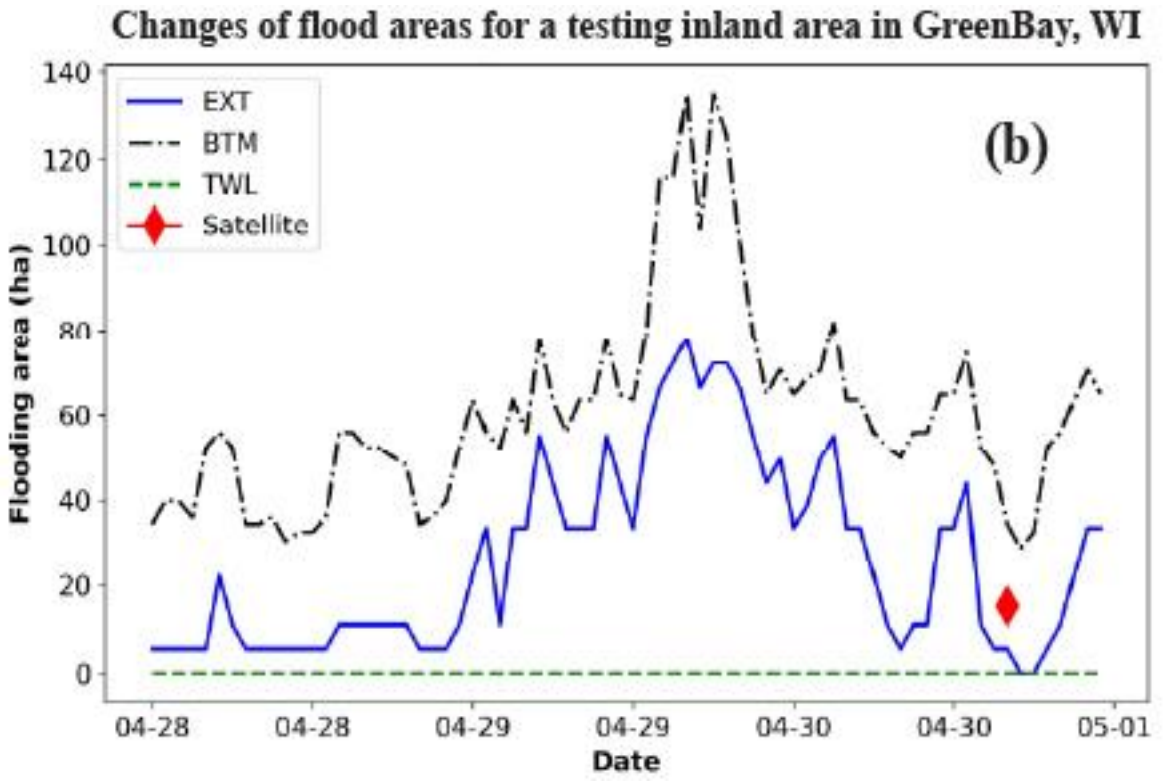




Model Verification Against SAR data

- High-resolution satellite image required for the Great Lakes region, as coastal flood only extend several tens to hundreds meters
- Synthetic aperture radar (SAR) is useful, but limited by its revisiting frequency, only one image was collected 23 hours after peak





Models for Social Vulnerability Analysis

- Complex shorelines and river-mouth areas in the Great Lakes, flow pathways usually not directly connected to shorelines, conventional wave run-up model incapable of capturing flooding in inland low-lying areas.

- Extended grids seem a promising approach, but difficult to cover the entire coastal areas of the Great Lakes.

- BTM has acceptable performance, could provide preliminary indication of areas that may be vulnerable to flooding, particularly for large study regions.

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Social Vulnerability Analysis

Step 1: Simulate flood extents at the Census Tract scale

Step 2: Analyze the distribution of different groups of people living in flood & non-flood prone areas

Step 3: Multivariate regression of socially vulnerable groups and flooding areas, assess coefficients

CATEGORY	DEFINITION
65 and Older	Individuals ages 65 and older.
Minority	Individuals identifying as Black, or African American; American Indian or Alaska Native; Asian; Native Hawaiian or Other Pacific Islander; and/or Hispanic or Latino.
No High School Diploma	Individuals ages 25 and older with a maximum educational attainment of less than a high school diploma or equivalent.
Low Income	Individuals living in households with income that is at or below 200% of the poverty level.

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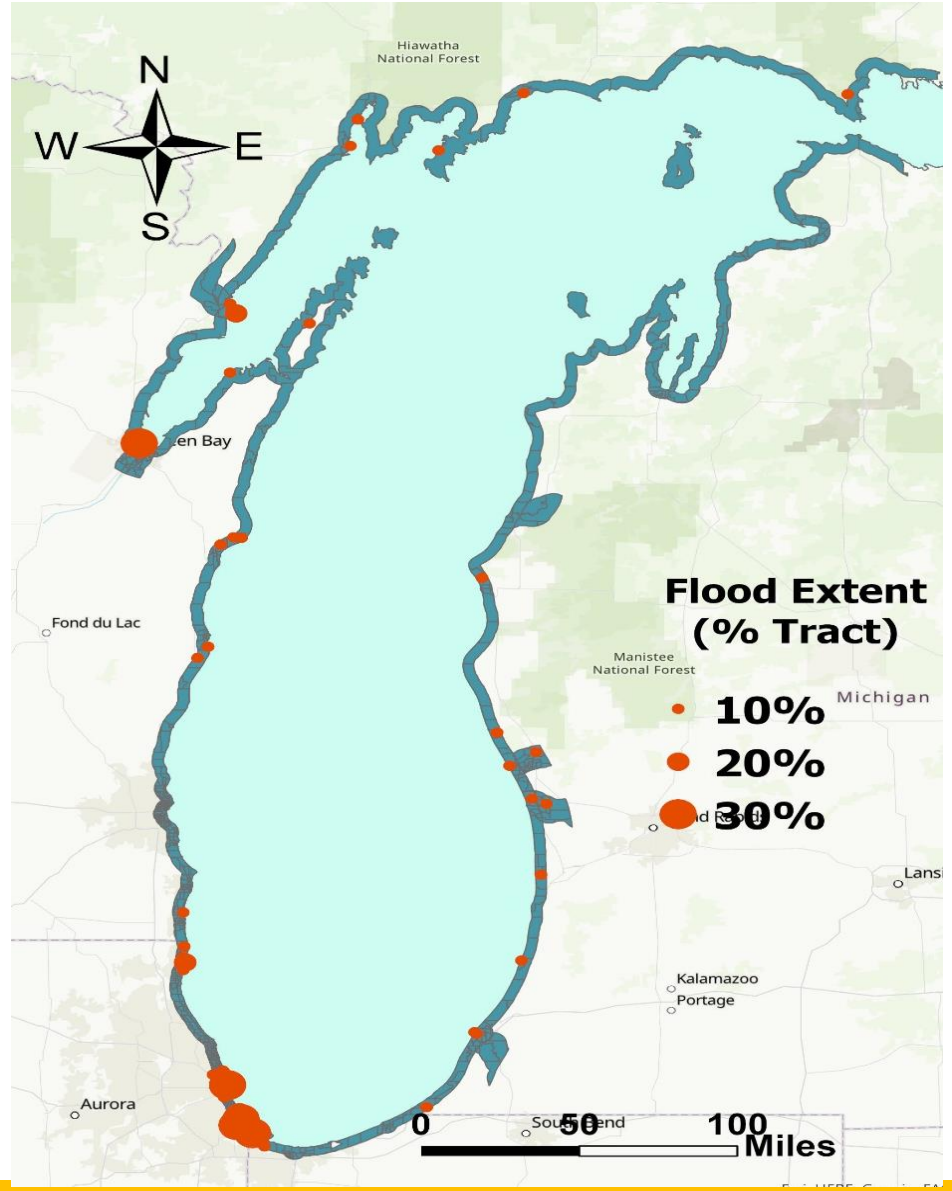
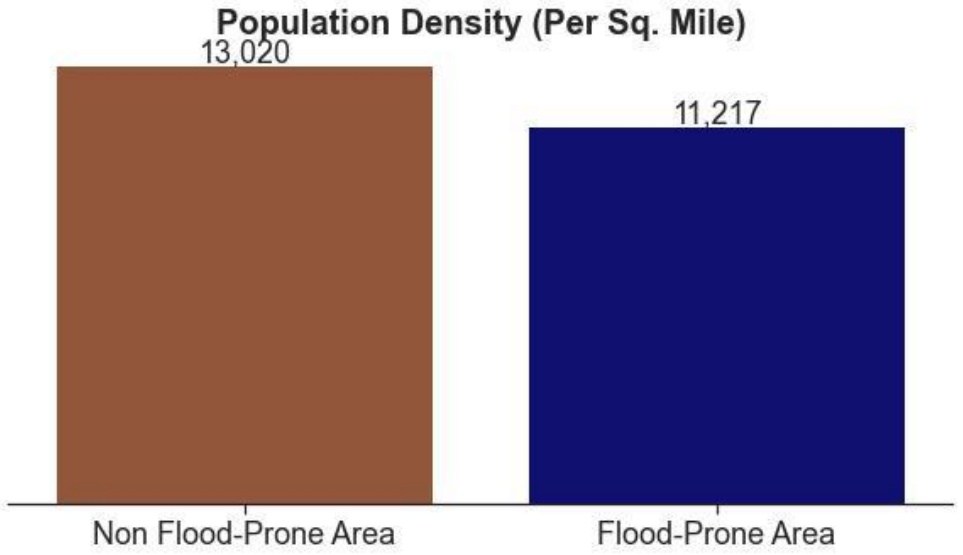
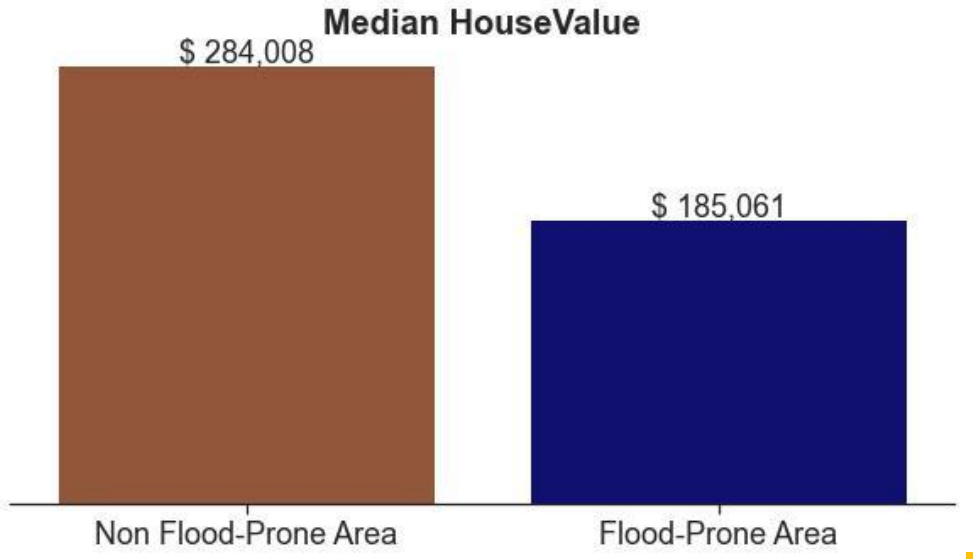
Flood-Prone Areas



Preliminary analysis of Population and Median House Value





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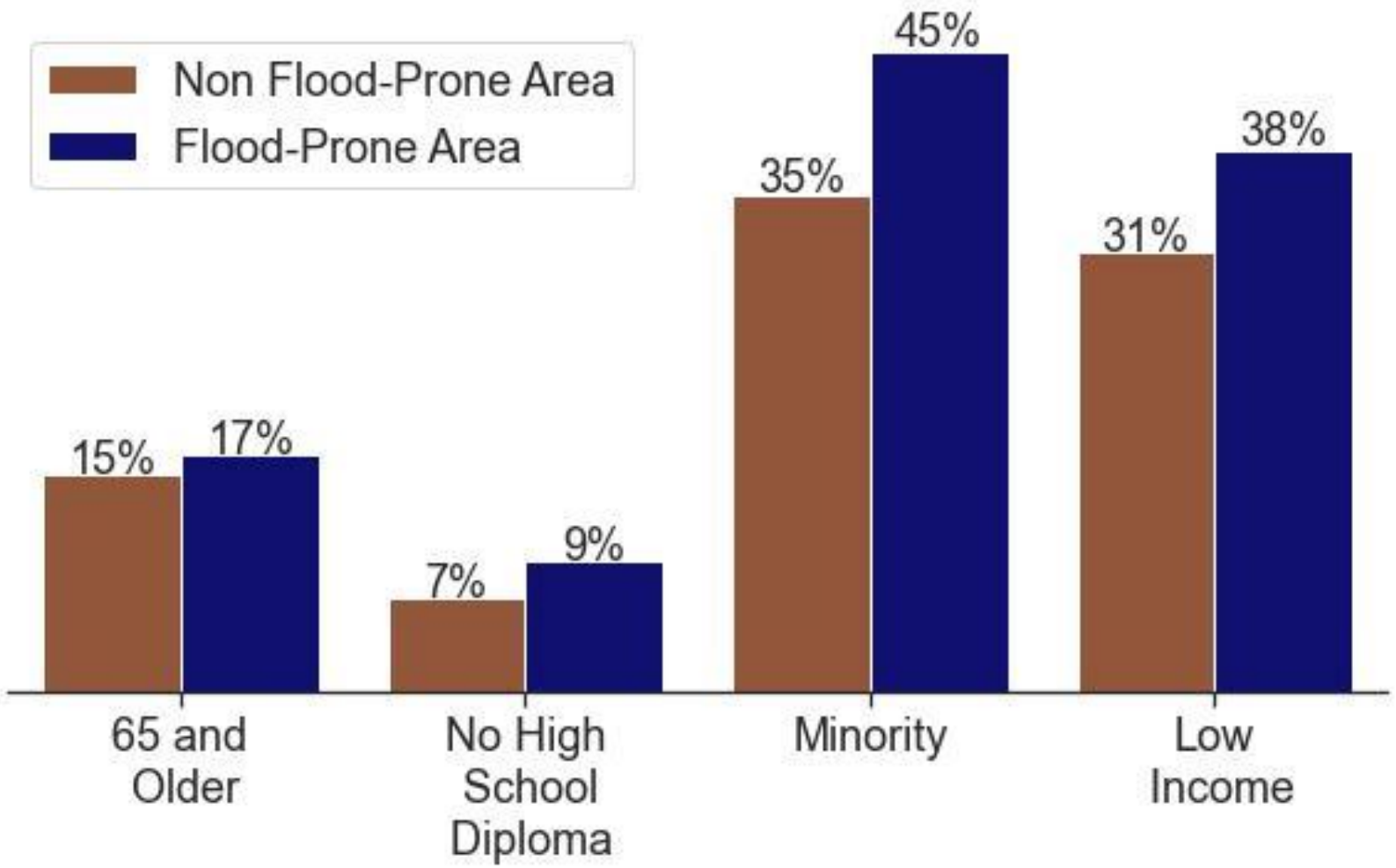
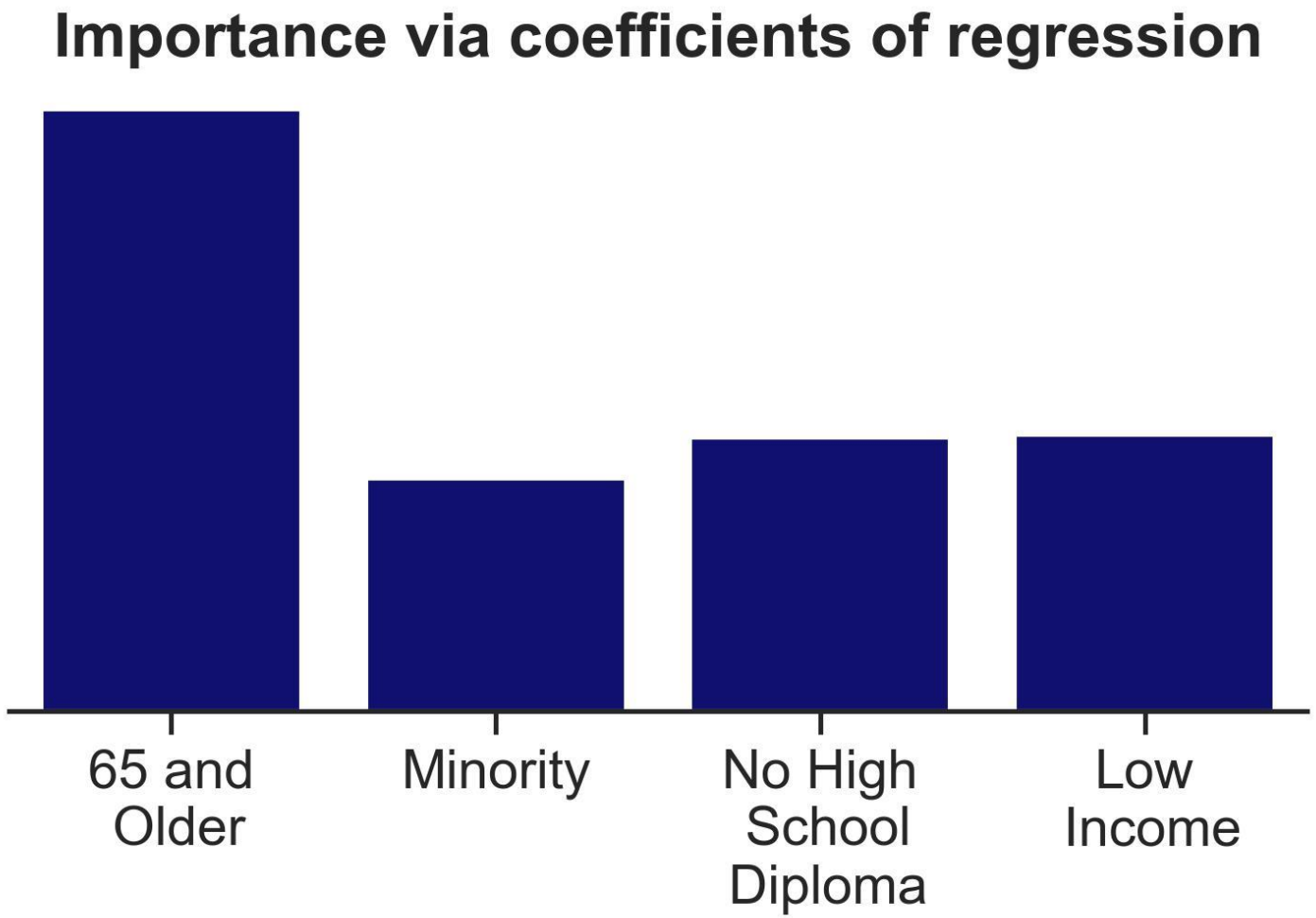
Distribution of Socially Vulnerable Populations In Different Areas



Socially Vulnerable populations face disproportionate high flooding risks

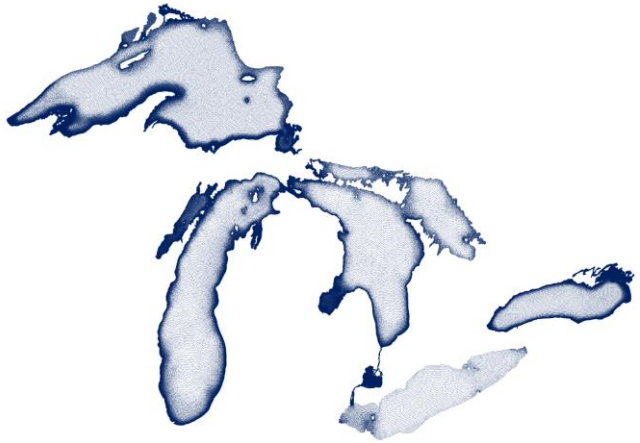
Multivariate regression and coefficient analysis



Older people are more likely to be impacted by coastal flooding

Conclusion and Ongoing Research

- Using Bathtub Model and operational coastal flood simulations to estimate flood extent at the census-tract scale.
- Socially vulnerable populations, particularly older people face disproportionate high flooding risks.



(NOAA - GLERL)

- Flood social analysis for the entire Great Lakes coasts.
- Analysis at building scale, building values, and incomes.
- Impact of climate change.

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