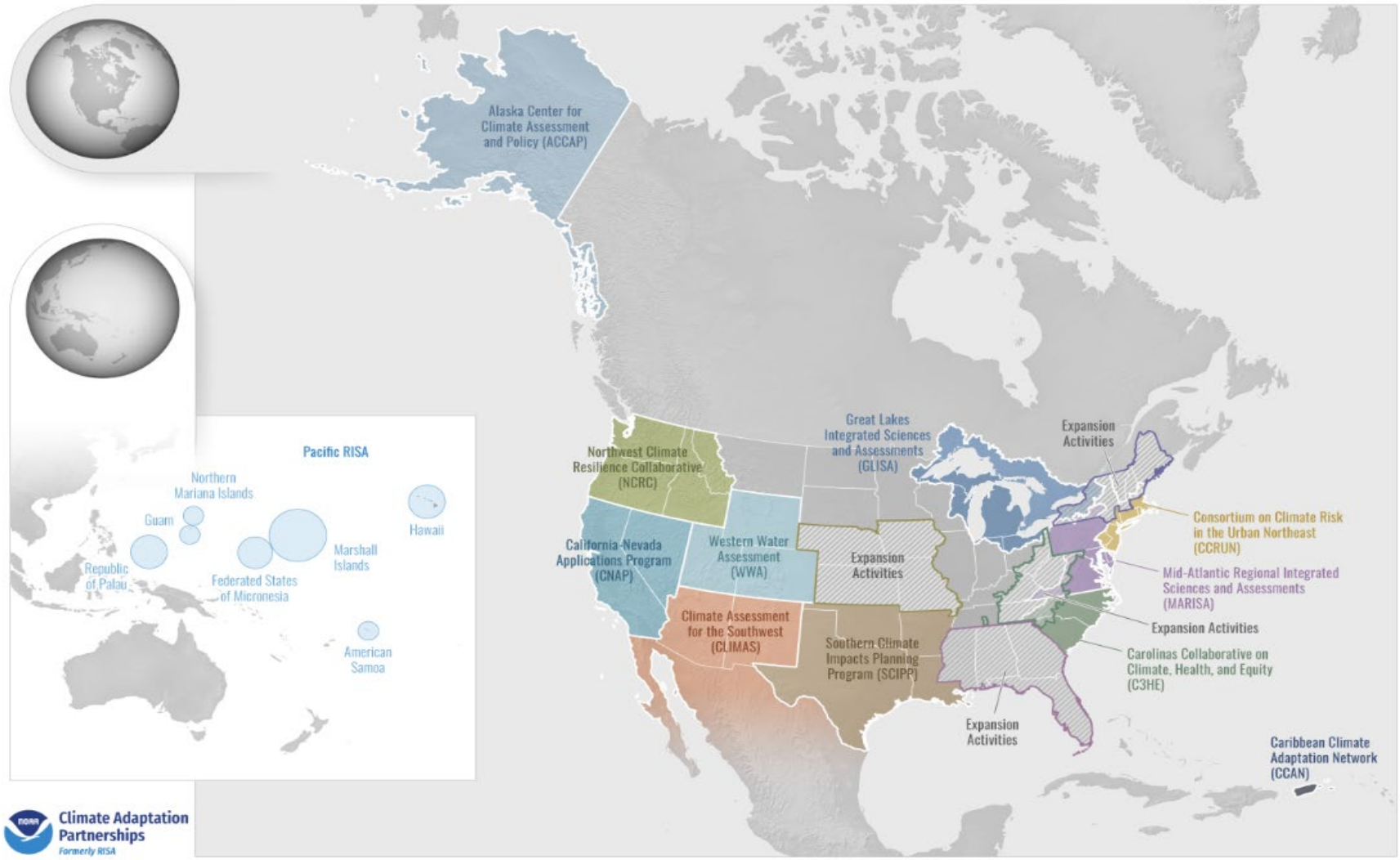
Climate Trends and Impacts in the Great Lakes Region

Photo: Dan Brown

NOAA Climate Adaptation Partnerships (CAPs)

Regional teams that help the nation to prepare for and adapt to climate variability and change



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GLISA's Approach

Research

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Integration
Collaboration
Extension

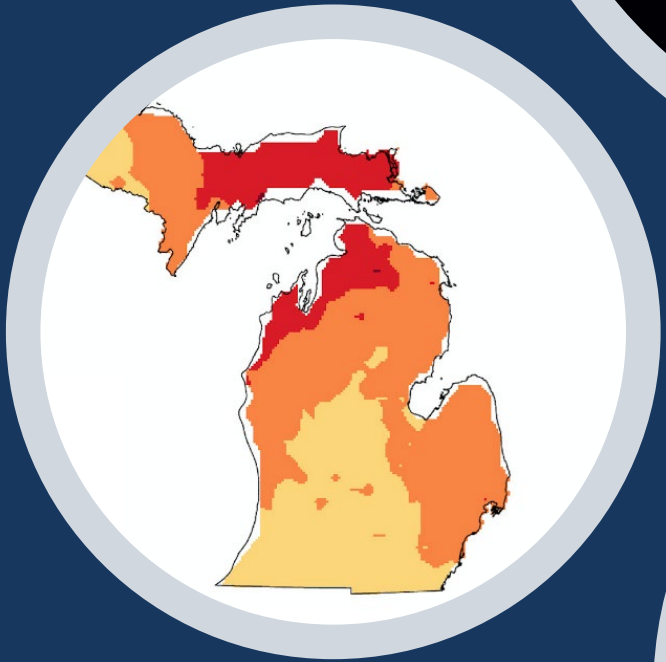
Service

- Interpret *existing* information and data for stakeholders
- Provide *locally* relevant climate synthesis:
  - What has happened?
  - What could happen?
  - What are the impacts?

Global | Regional | Local

- There are multiple ways of looking at climate change:
  - Global
  - Regional
  - Local

- Local factors can drastically alter the magnitude of climate change impacts, but can also be adapted to more readily.



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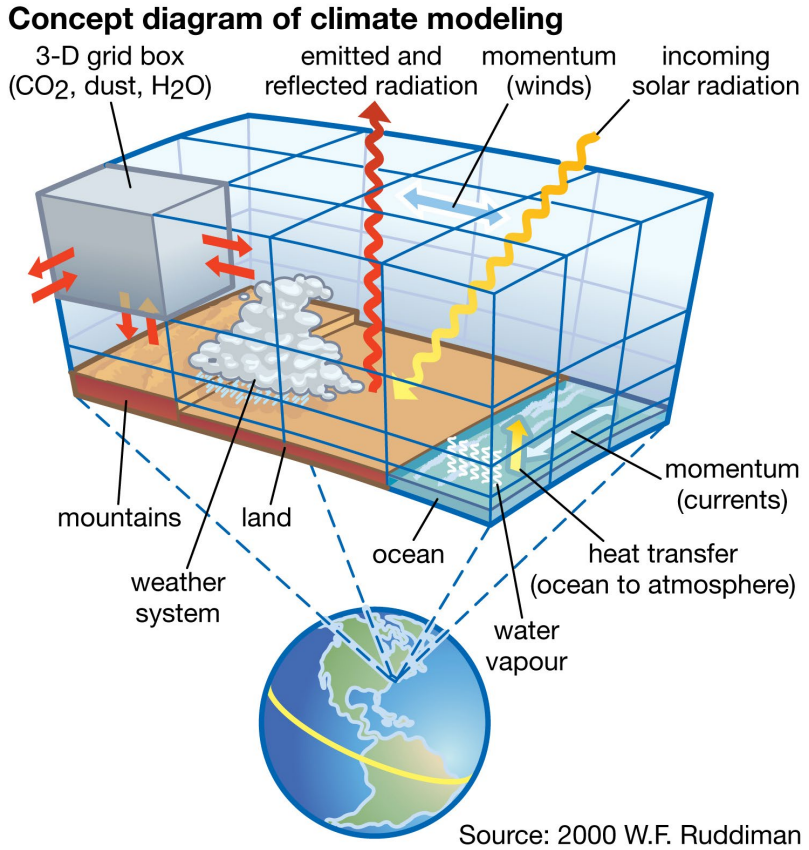
Why do We Trust the Climate Models?

- Visualizing the planet changing
  - Uses complex mathematical equations for predicting plausible future patterns
    - Based on Earth's energy balance
  - Simulates Earth system processes
    - Air, Land, & Oceans
    - Show the same results as past weather observations and dynamics
- Great Lakes Ensemble
  - GLISA's model evaluation for the region
    - Test whether models include the Great Lakes and the proper dynamics associated with the changing climate
- University of Wisconsin-Madison Regional Climate Model Version 4 (UW-RegCM4)
  - Provides sufficient representation of the land-lake-atmosphere dynamics for the Great Lakes region



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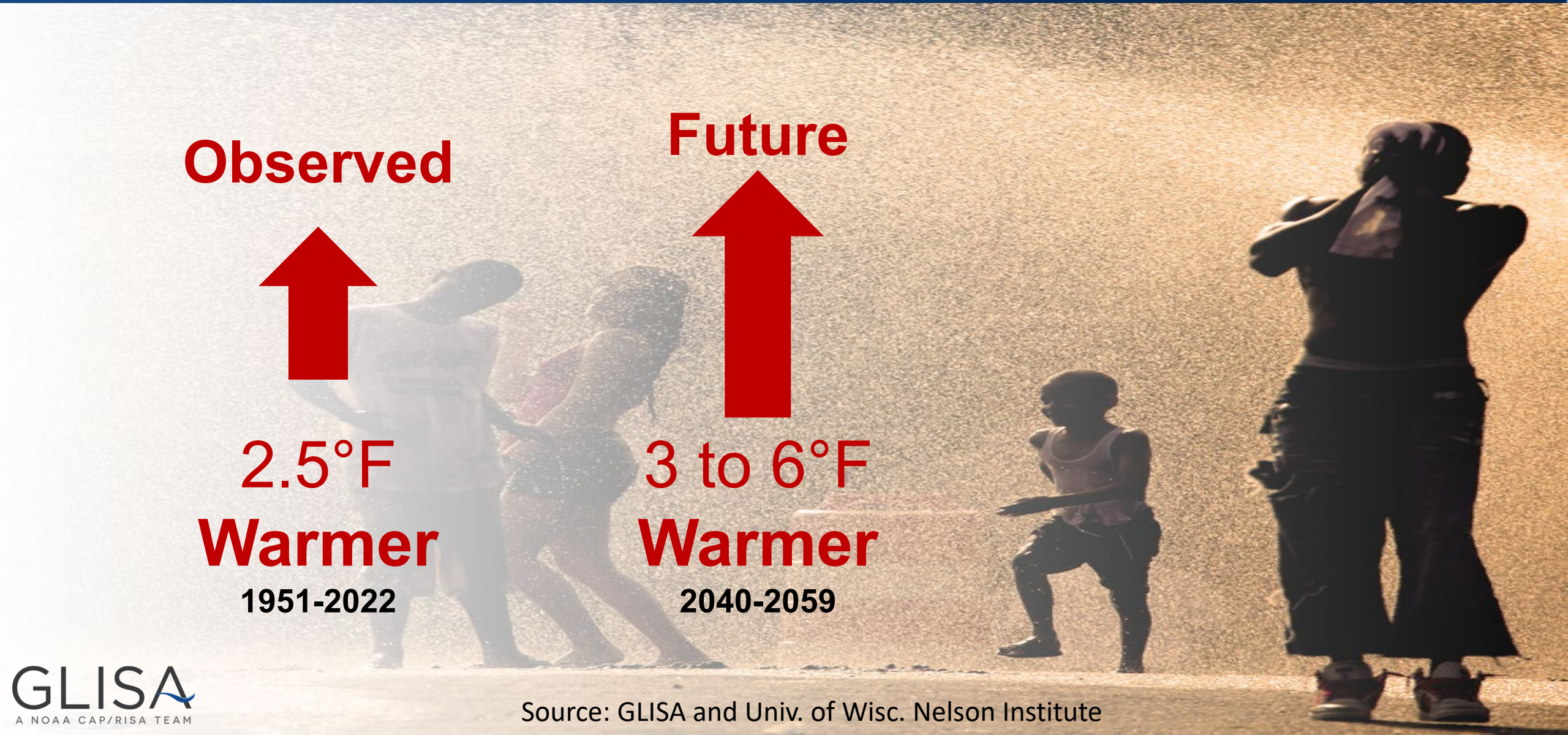
Global | Regional | Local

Photo credit: http://www.noaa.gov/resource-collections/great-lakes-eco-region

Rising Temperatures



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Source: GLISA and Univ. of Wisc. Nelson Institute

Winters are Warming Faster

2.5°F increase averaged over the entire **year**

3.8°F increase during **winter** **(December - February)**

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Source: GLISA & National Centers for Environmental Information

Photo: Dan Brown

A Longer Frost-free Season

Observed

16 Days

Longer

1951-2022

Future

15 to 24 Days

Longer

2040-2059

Observed changes due mostly to **earlier last winter freeze**

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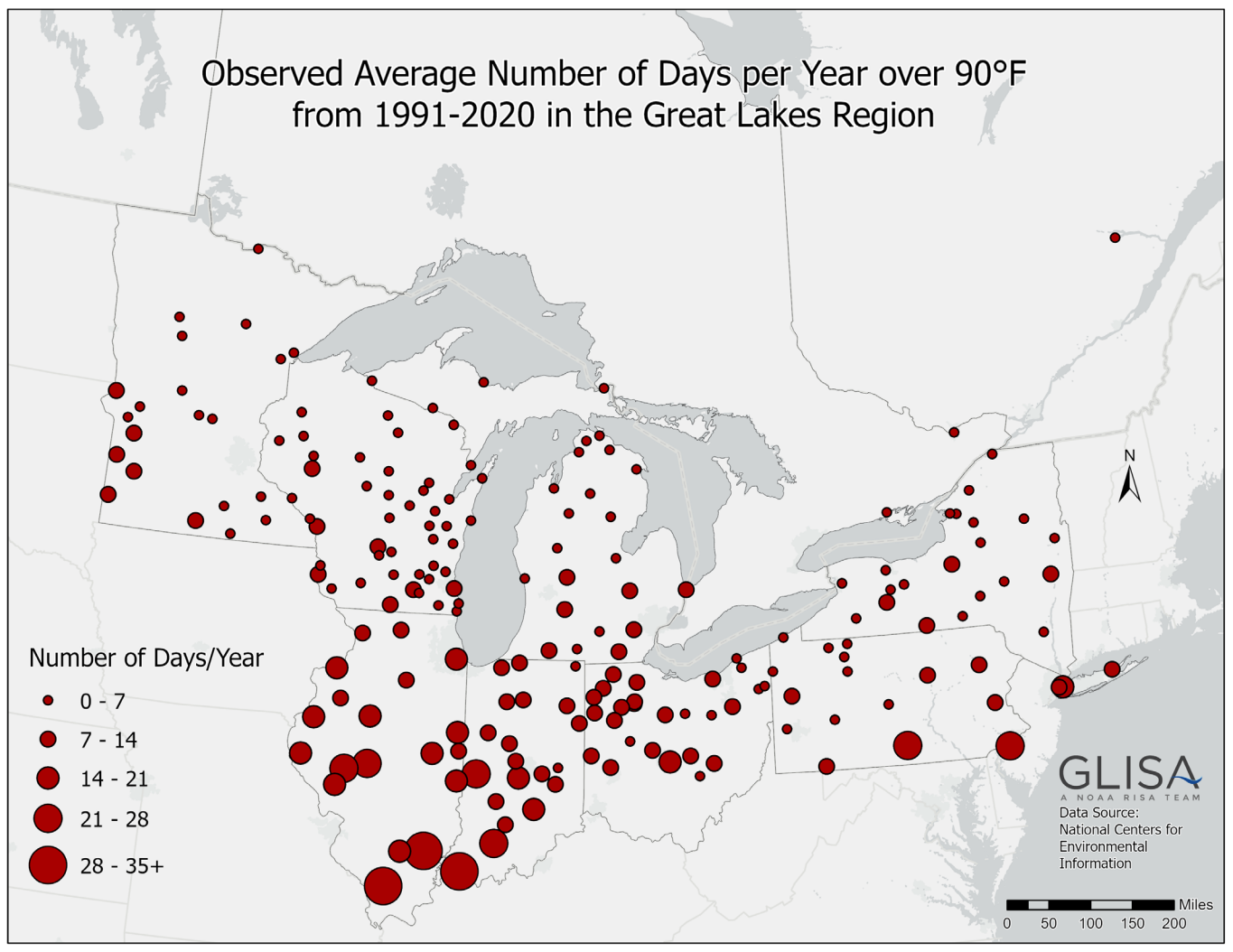
Source: GLISA and Univ. of Wisc. Nelson Institute

Extreme Heat

Average Number of Days over 90°F in the Great Lakes region has increased by:

7.7 Days



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Source: National Centers for Environmental Information

Extreme Heat and Humidity

By mid-century, models project the region could see:

90°F Days

9 to 37 more days per year

100°F Days

3 to 19 more days per year*

But, it is unclear if there has been a significant observed change in hot days.

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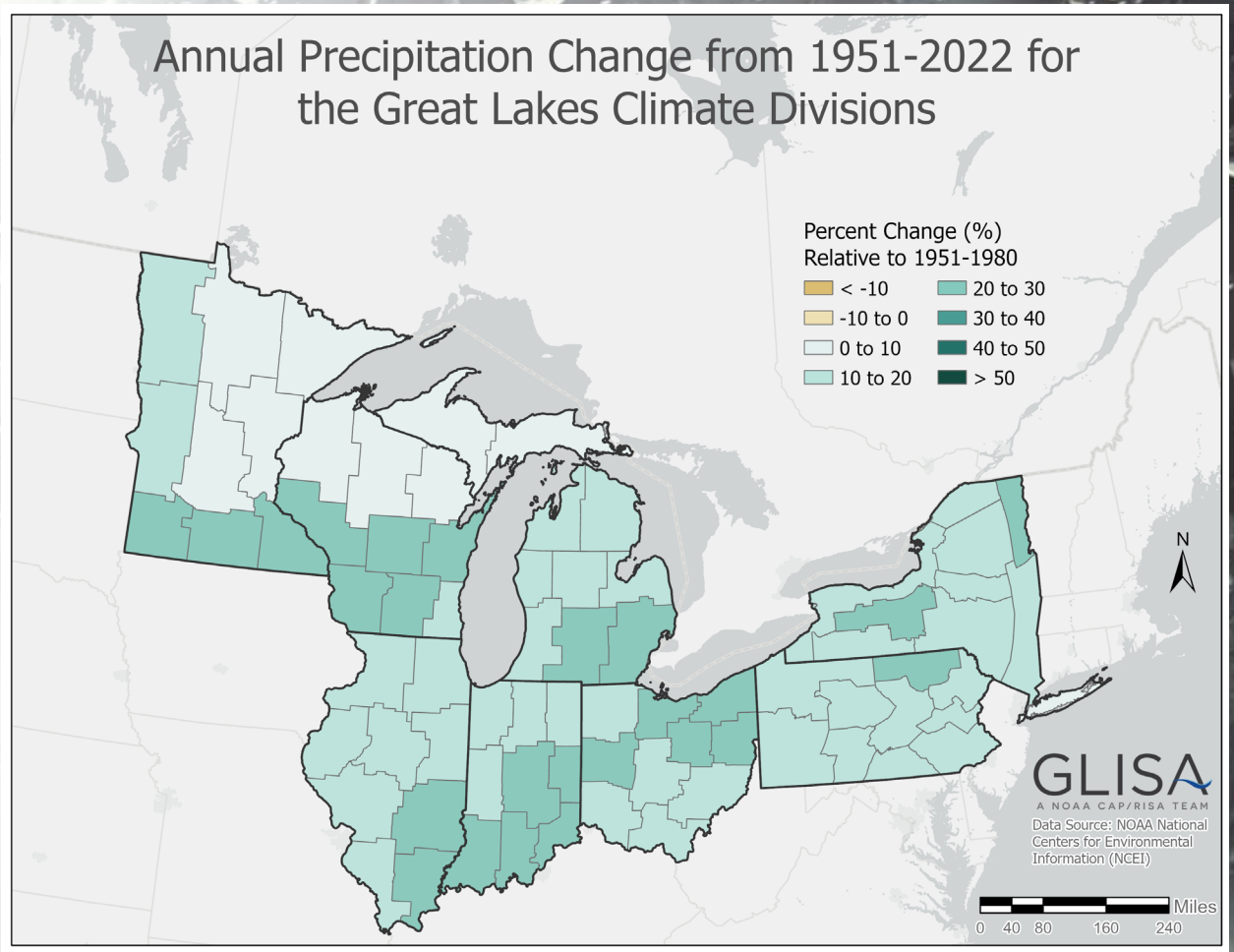
Source: GLISA and Univ. of Wisc. Nelson Institute

More Precipitation

Total annual precipitation in the Great Lakes region has increased by:

17%



Uneven changes across the Region

Percent change are calculated relative to the period of 1951-1980 historical reference period.

Source: National Centers for Environmental Information

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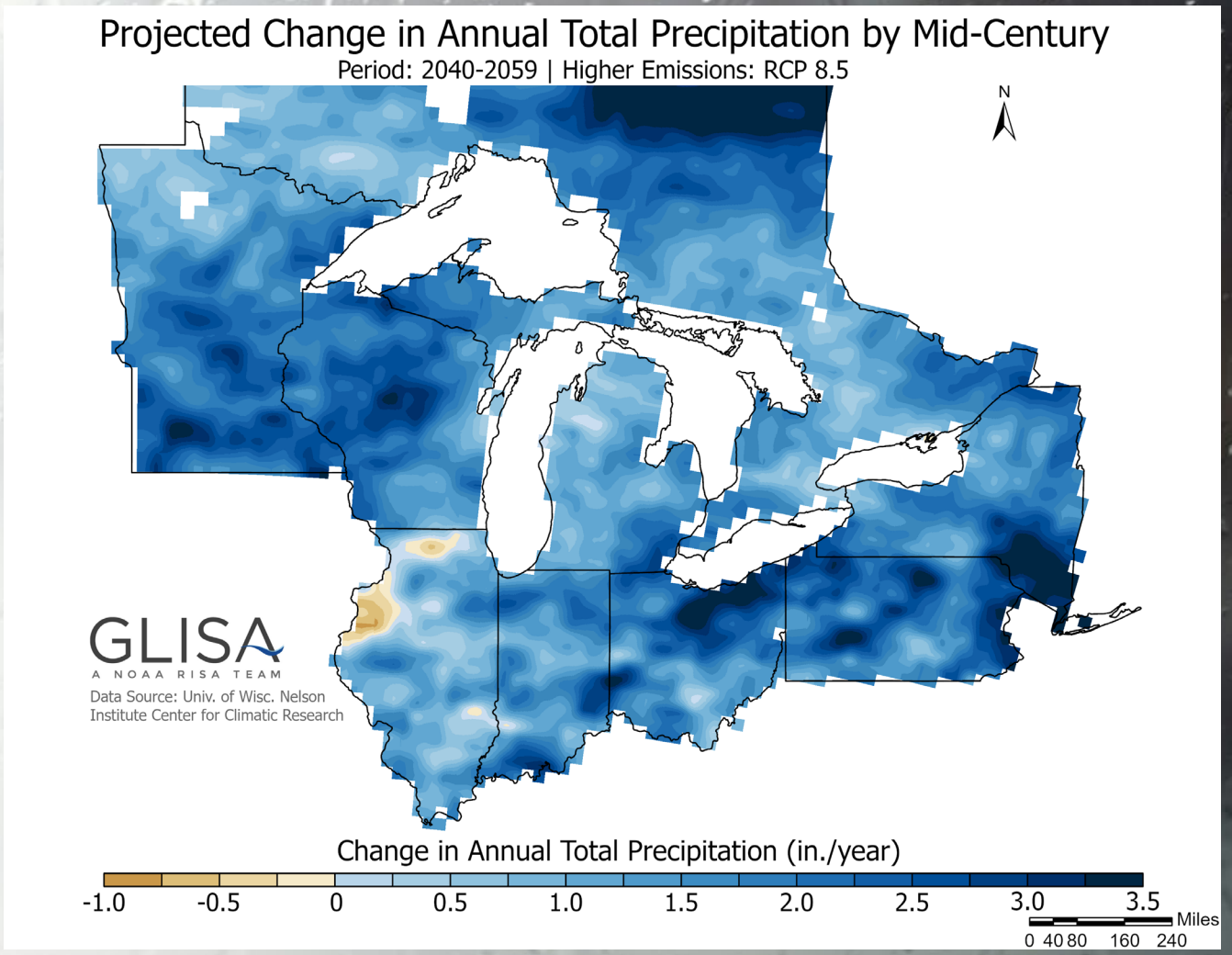
More Precipitation

Future projections suggest varying amounts in the region by mid-century.

-0.25 to 4.24 inches



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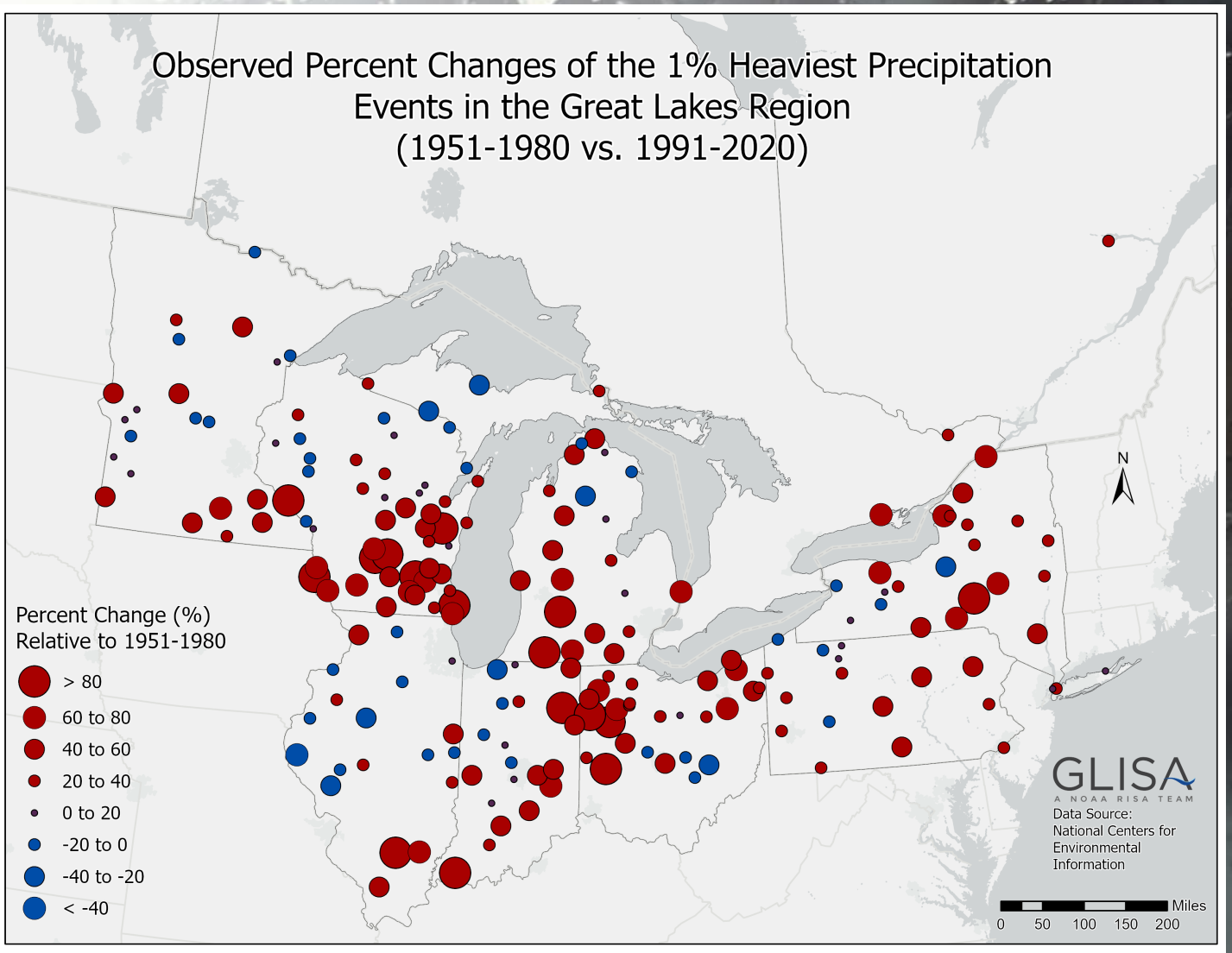
Source: University of Wisconsin-Madison Nelson Institute Center for Climatic Research

More Extreme Precipitation

1% Heaviest Precipitation Events:

35%

Nuisance flooding and minor damages are reported more frequently after these events



Source: National Centers for Environmental Information

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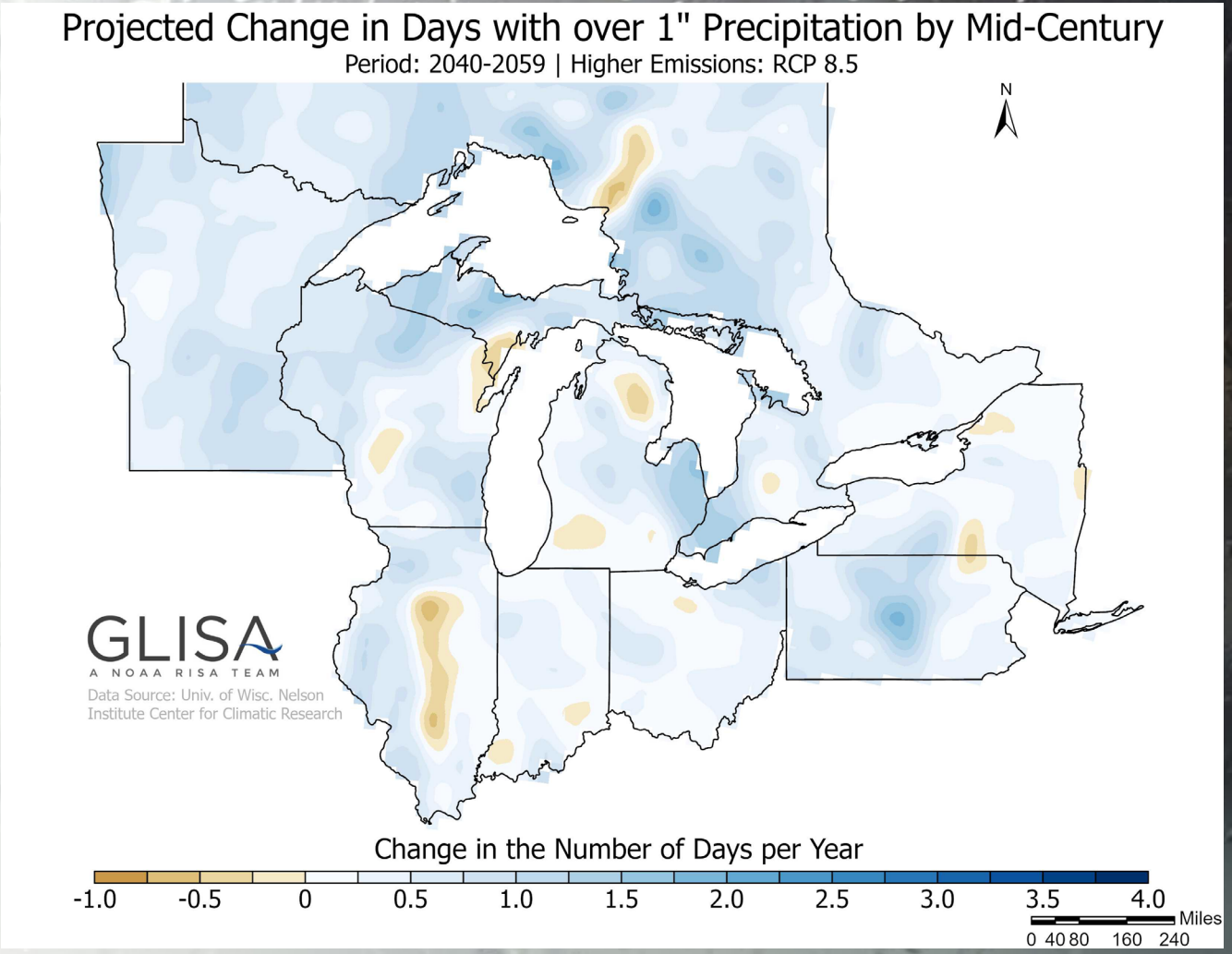
Extreme Precipitation

Mid-Century

Greater than 1-inch Precipitation Days:

0.4 to 1.5 days more per year

2040-2059



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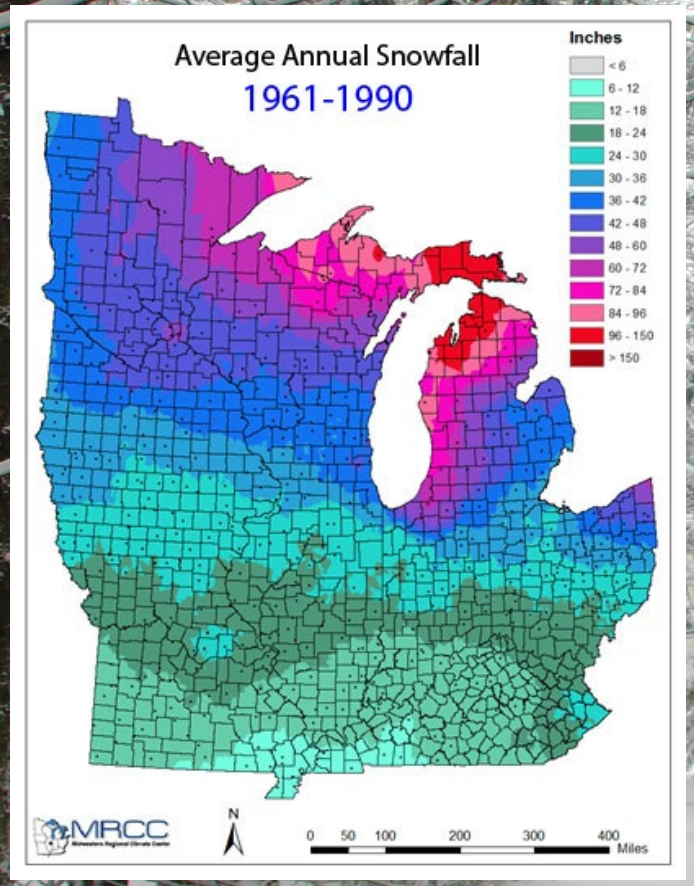
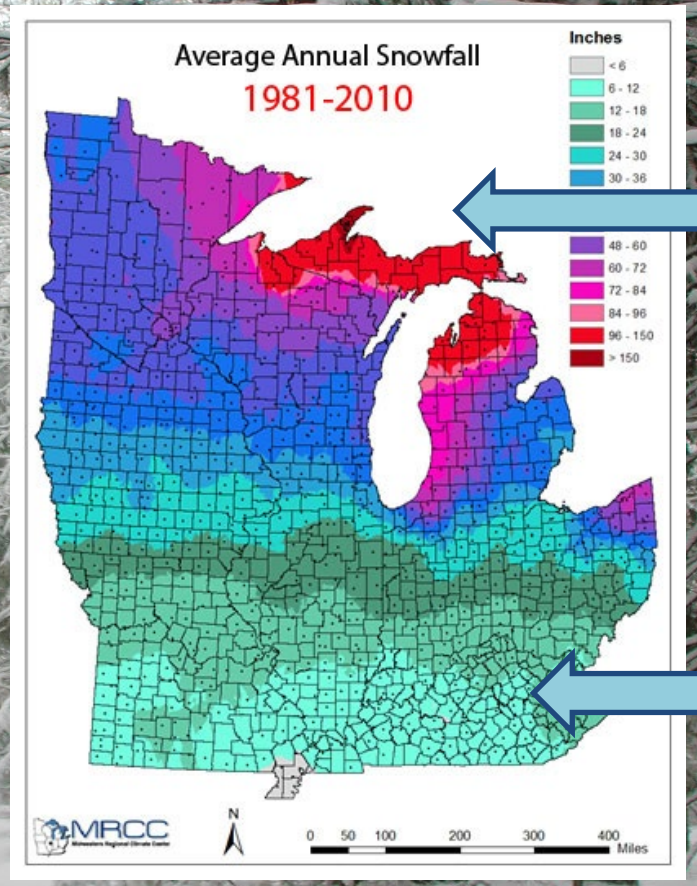
Source: GLISA, National Centers for Environmental Information, & U of Wisc. Nelson Institute

Change in Snowfall





Snowfall has increased in lake-effect areas

Snowfall has remained stable or decreased throughout southern parts of the region

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Photo: Kim Channell

Impacts

Photo: Dan Brown

Climate Hazards

Risk	By Mid-Century
Convective Weather	↑
Severe Winter Weather	↑
Extreme Heat	↑
Extreme Cold	↓

Risk	By Mid-Century
Dam Failures	↑
Flood Hazards	↑↑
Wildfires	↑
Drought	↑

Stormwater Impacts

- Intense, flashy runoff amplify flooding risks.
- Road and infrastructure damage
- Erosion
- Sewage overflow
- Stormwater drainage systems designed for historic conditions

David Archambeau

2018 flood damage in Houghton, MI

DroneBase via AP

2018 Ohio River flooding in Cincinnati, OH

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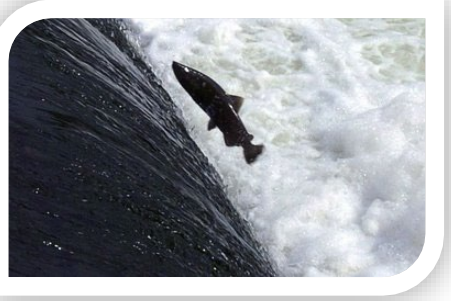
Plants and Wildlife

- Forest ecosystems forced northward
  - Maple-Beech-Birch forest displaced
- Amplified stressors on biodiversity
  - Declining Coldwater fish populations, species migrating northward
- Agriculture
  - Longer growing season
  - Water availability, warm spells, spring freezes, flooding, and drought will reduce crop yields



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Algal Blooms and Water Quality

More/Stronger Storms

More Runoff from Agriculture

Greater Nutrient Loading

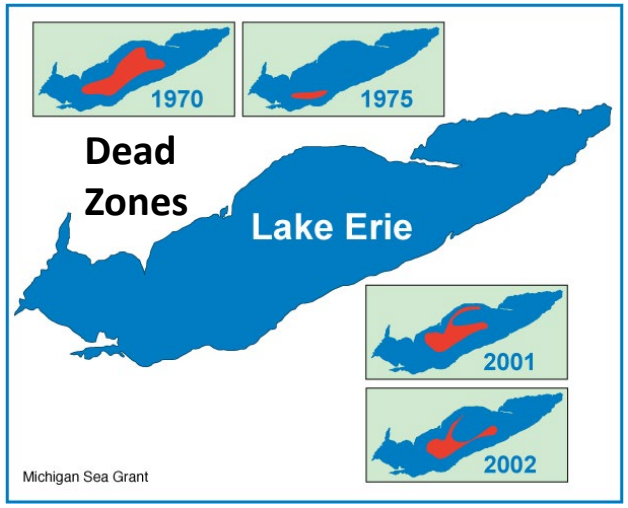
Warmer Lake Temperatures

Changed Lake Dynamics

Algal Blooms

Dead Zones

NOAA



MI Sea Grant

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Lake Levels

Main drivers of water supply on the lakes are:

- Precipitation - Evaporation + Runoff
- All three drivers are affected by regional climate change

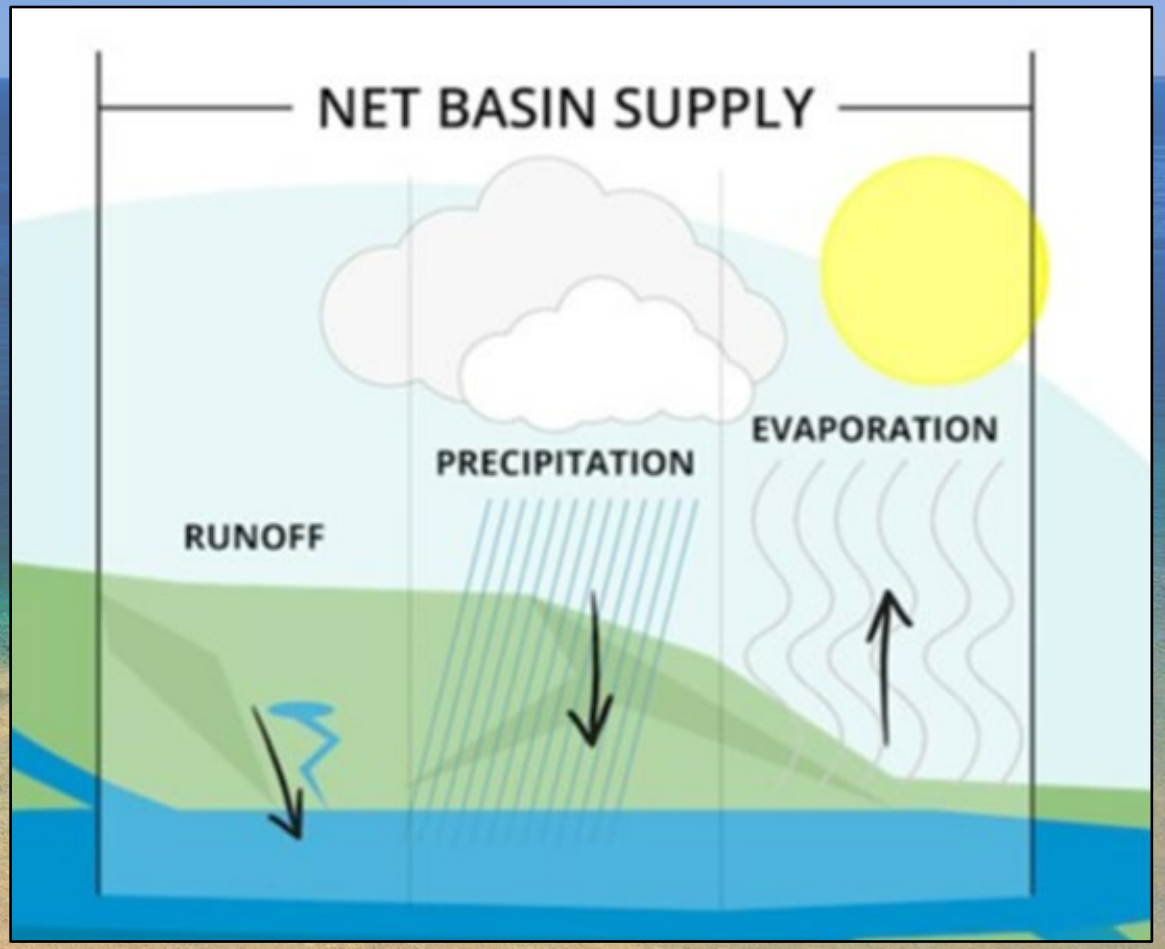

Image modified from NOAA Great Lakes Environmental Research Laboratory (GLERL)

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Photo: Dan Brown

Future Lake Levels

- Future water level changes will depend on whether precipitation or evaporation dominate
- Short-term variability with periods of high and low lake levels are still anticipated

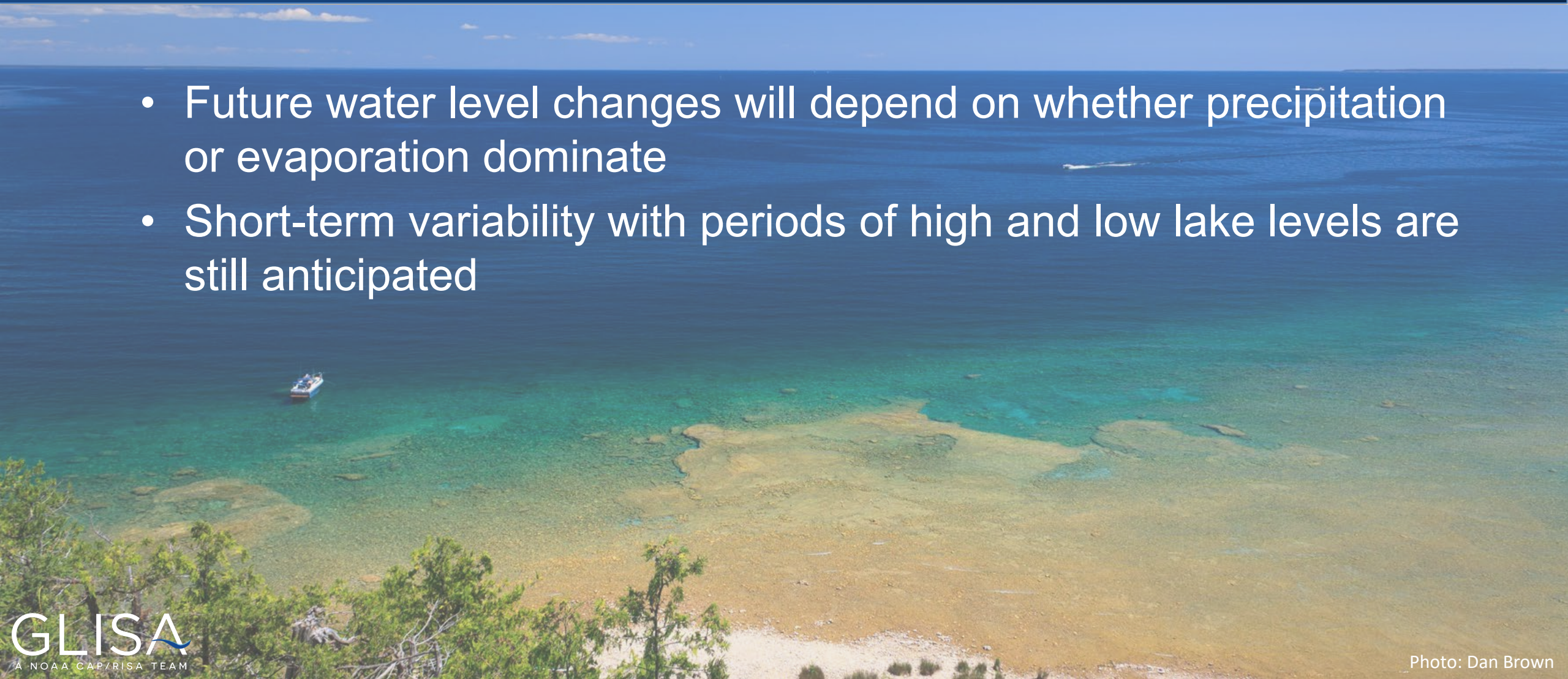

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Photo: Dan Brown

Lake Level Projections

- Lake level projections can be obtained from combining climate models with lake models
  - Inadequate representation of lake physics in the models
  - This introduces uncertainty and bias
  - Greater variability and extremes anticipated in the future
- Scenario planning is a method to manage that uncertainty

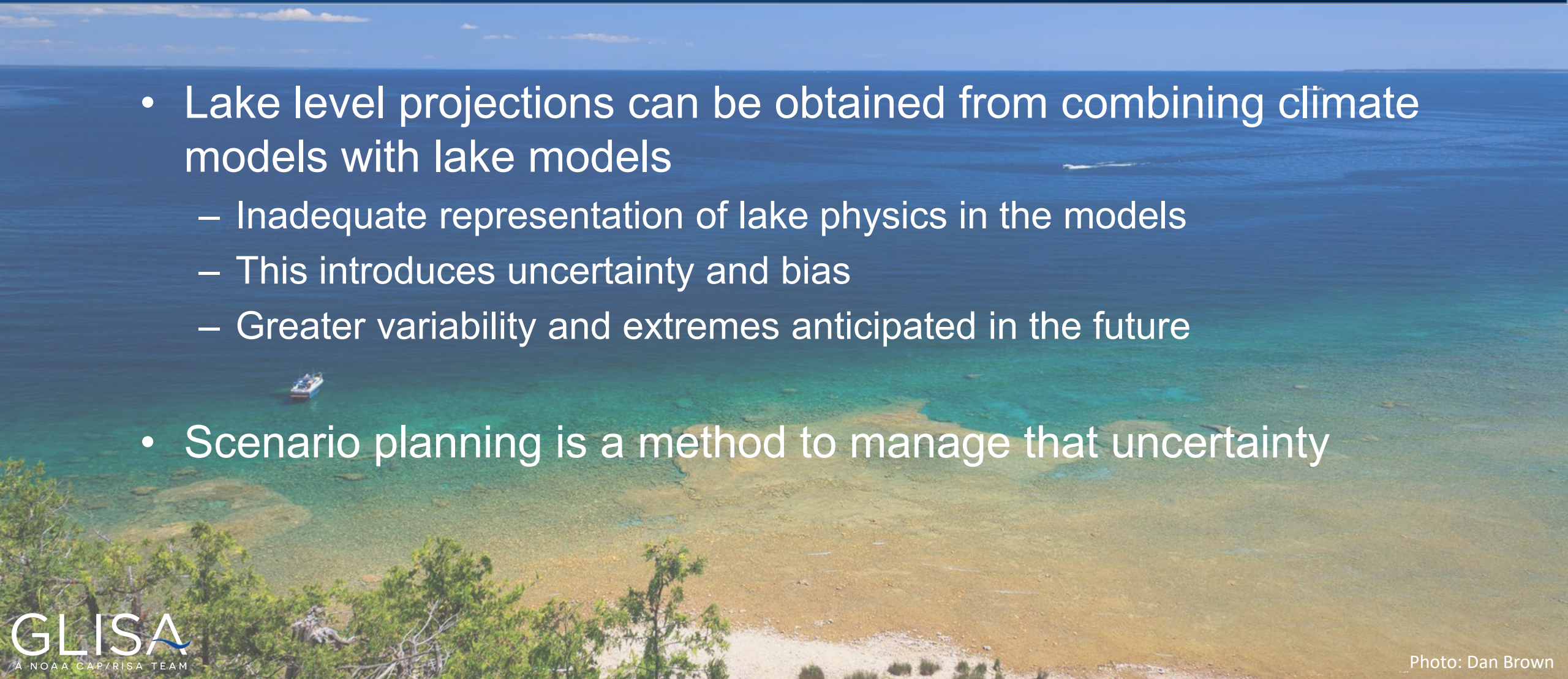

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Photo: Dan Brown

Impacts of Lake Levels

- Boating and recreation
- Shipping and navigation
- Property
- Fisheries and wetlands

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Photos: Kim Channell

Great Lake Shoreline Flooding and Erosion

- High wind and waves accelerate erosion
  - Winter events can lead to ice shoves and further shoreline and infrastructure erosion
- Many instances of flooding from high lake levels in recent years

2017 Flooding & Erosion on Lake Ontario, NY.

Photo credits: Coastal Flooding Survey Project, Cornell University and New York Sea Grant

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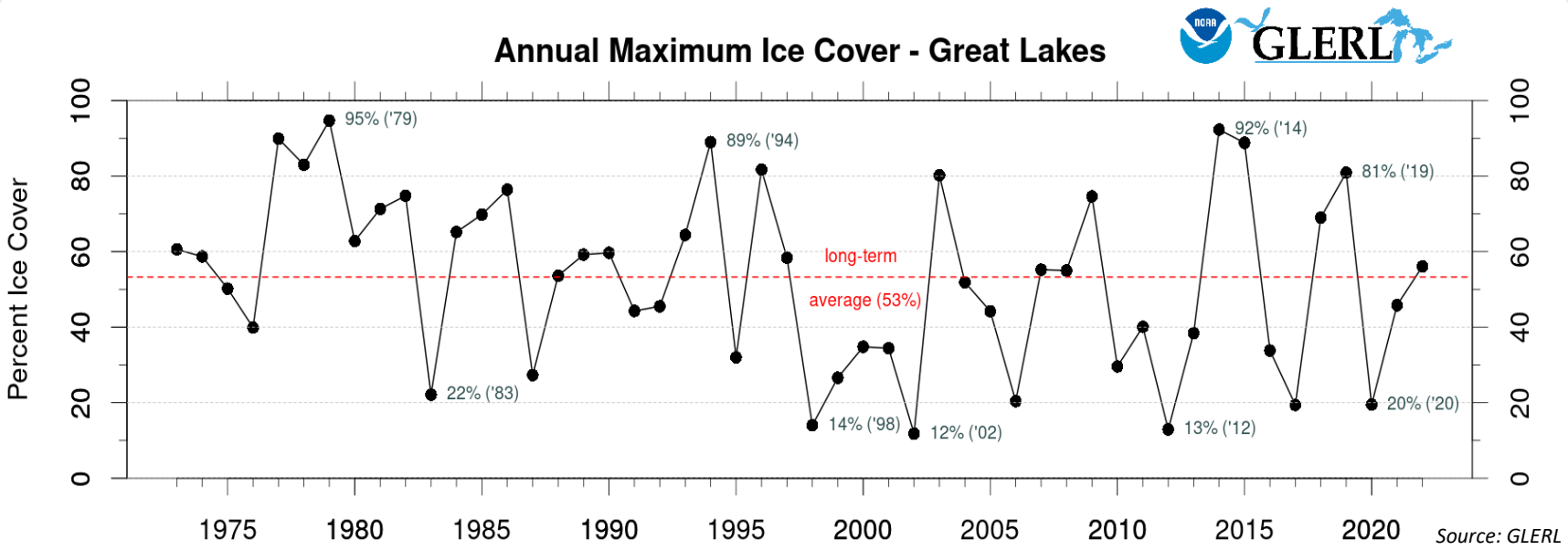
Impacts of Variable Great Lakes Ice Cover



- **Fishing Industry:** Ice cover protects whitefish spawning areas. Great Lakes commercial fishing is $4 billion industry.
- **Coastal Zone:** In nearshore areas, ice provides stable platform for recreation and protects wetland areas from erosion.
- **Water Levels and Navigation:** Heavy ice cover can reduce evaporation and contribute to higher water levels in the following seasons—good news for shipping.

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Potential Impacts on Shipping

Every lost inch of water depth:

- Reduces cargo capacity 50-270 tons
- Costs $10k-30k per transit.

…but less lake ice cover allows for a longer shipping season

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Scenario Planning

- **Objective:** A method to describe and incorporate uncertainty into decision making by developing a framework to plan for multiple plausible futures

- **GLISA's approach:** Develop a set of physically plausible lake level and/or climate scenarios for stakeholders to build upon in a live workshop and discuss goals and recommended actions

- **Scenarios informed by:**
  - Historic observations and trends
  - Guidance from climate model projections
  - Stakeholder input

Scenario Planning Visualization. Source: NPS (2022)

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GLISA Resources

- Guidance on current and future adaptation planning practices
  - Climate Change Scenario Planning Workbook
  - Climate Change Scenarios for Great Lakes Cities

- Many resources available for informing adaptation in the Great Lakes region
  - Climate Change in the Great Lakes Region Factsheet
  - Annual Climate Trends and Impacts Summary for the Great Lakes Basin
  - Climate Impact Summaries
  - Great Lakes Regional Climate Change Maps
  - Practitioners' Guides

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For More Information

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Photo: Kim Channell