# Climate Change and Marina Resiliency in the Great Lakes

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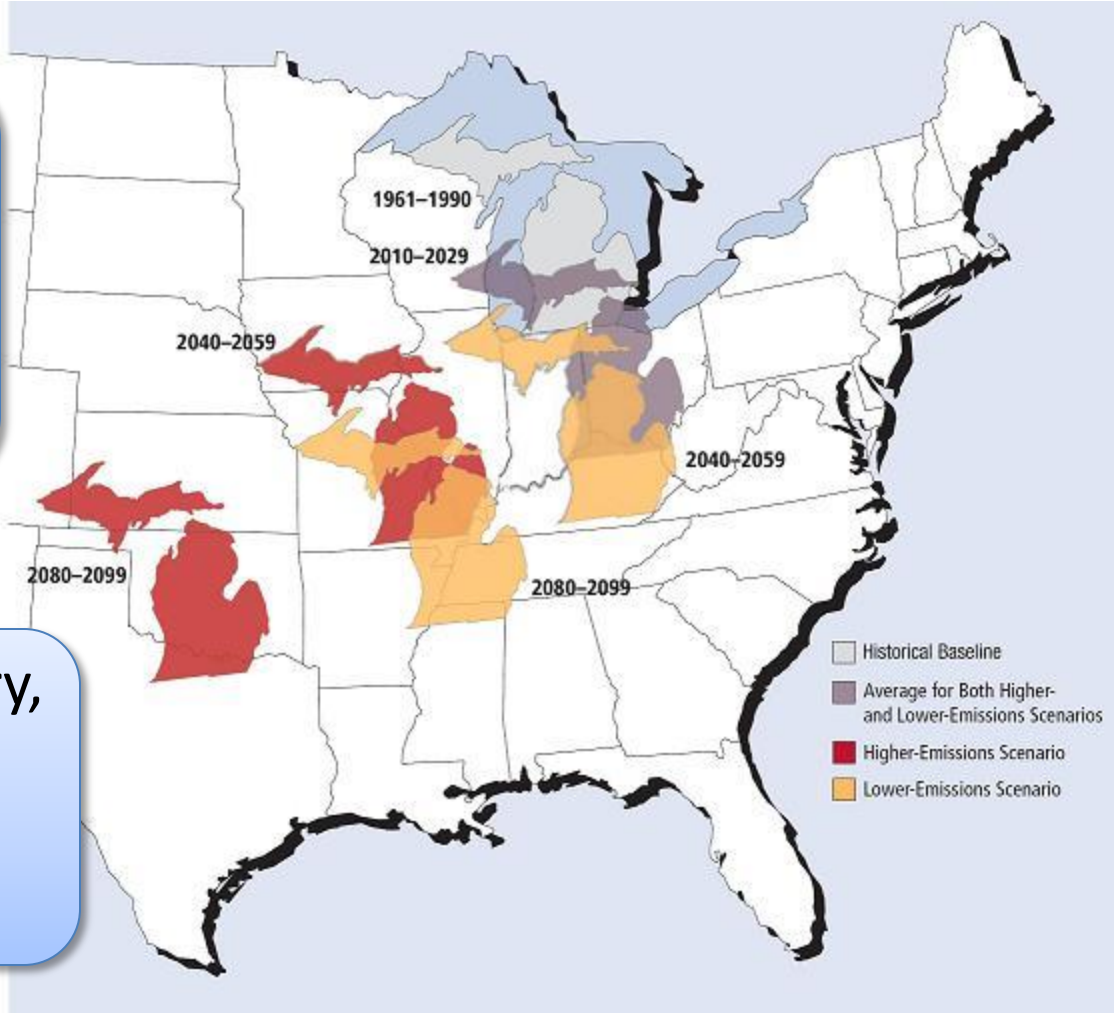
*Division of Parks & Watercraft*

# A Migrating Climate

The climate future generations experience will be fundamentally different than the climate today.

By the end of this century, Michigan summers will *feel* more like current summers in Arkansas.




Courtesy UCS 2009, original work by Hayhoe et al.

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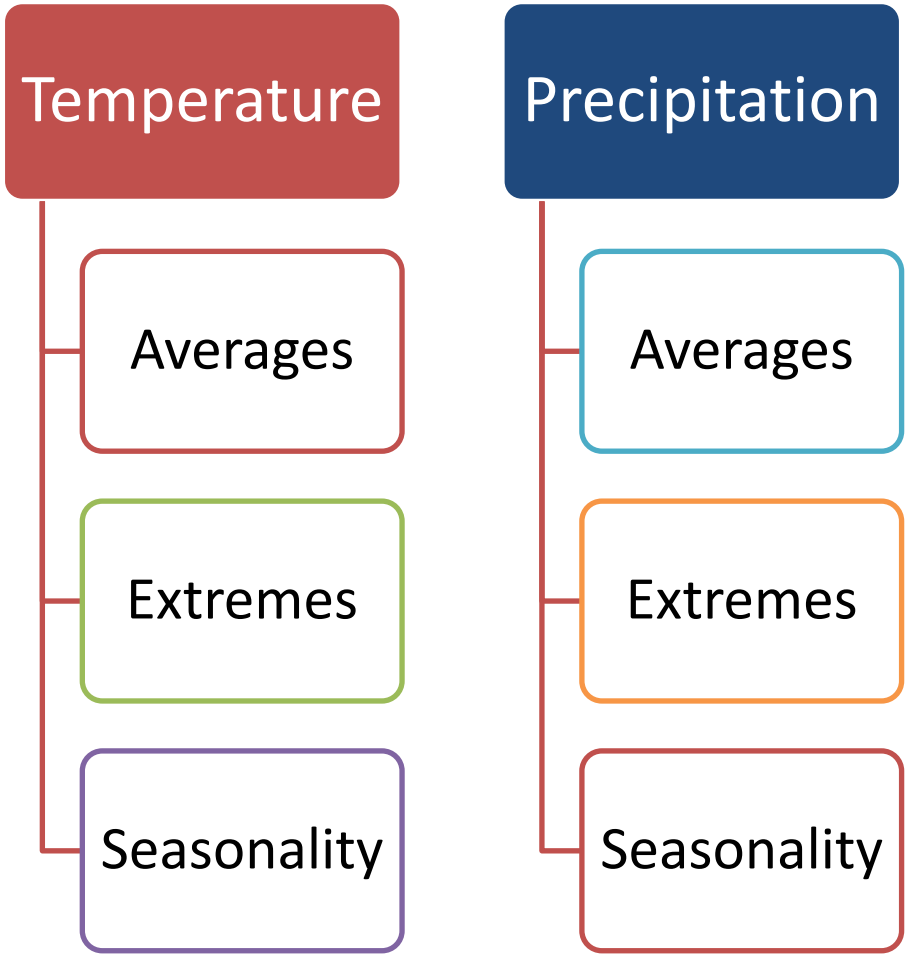
# What has Changed?




Scientists often discuss changes in terms of averages, but *our environments are managed in terms of timing and extremes.*

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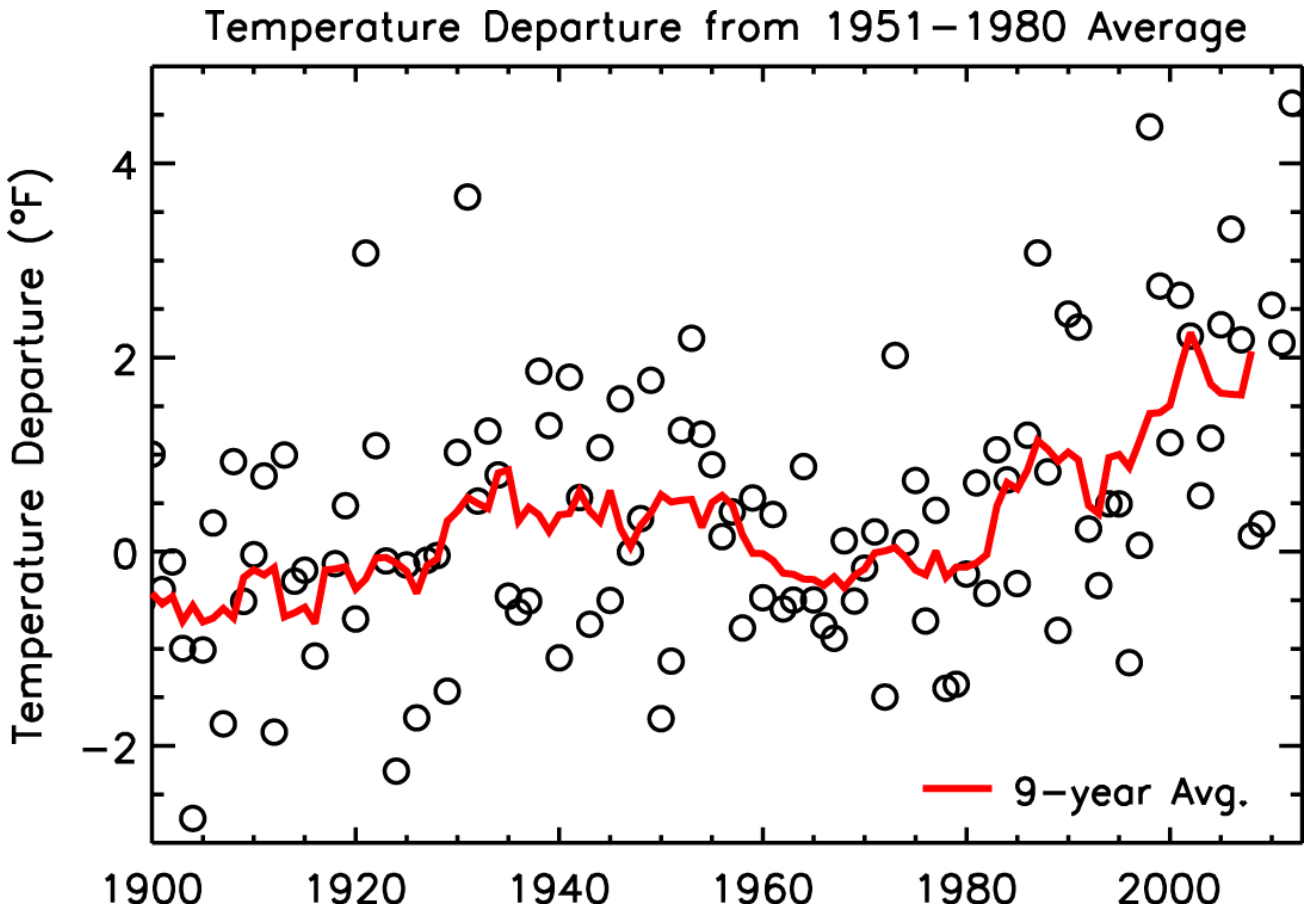
# Observed Regional Temperature




**2.0°F**
**1.1°C**
**1900-2012**

Winter temperatures and overnight low temperatures have increased faster than annual averages.

Weighted averages of nClimDiv divisional data from 8 U.S. Great Lakes States.

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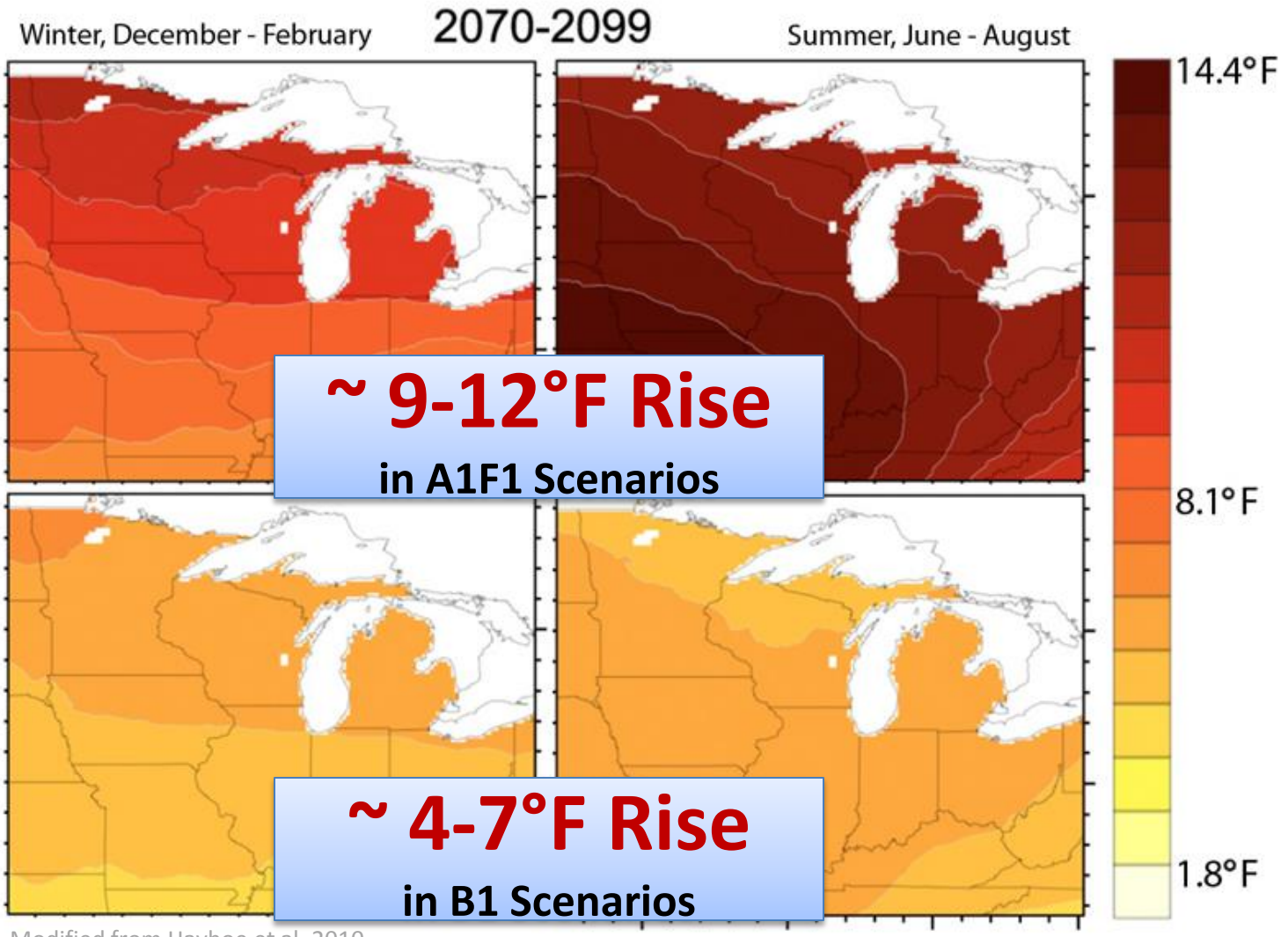
# Projected Midwest Temperature

**Very High** Emissions Scenario

**Low** Emissions Scenario




Modified from Hayhoe et al, 2010

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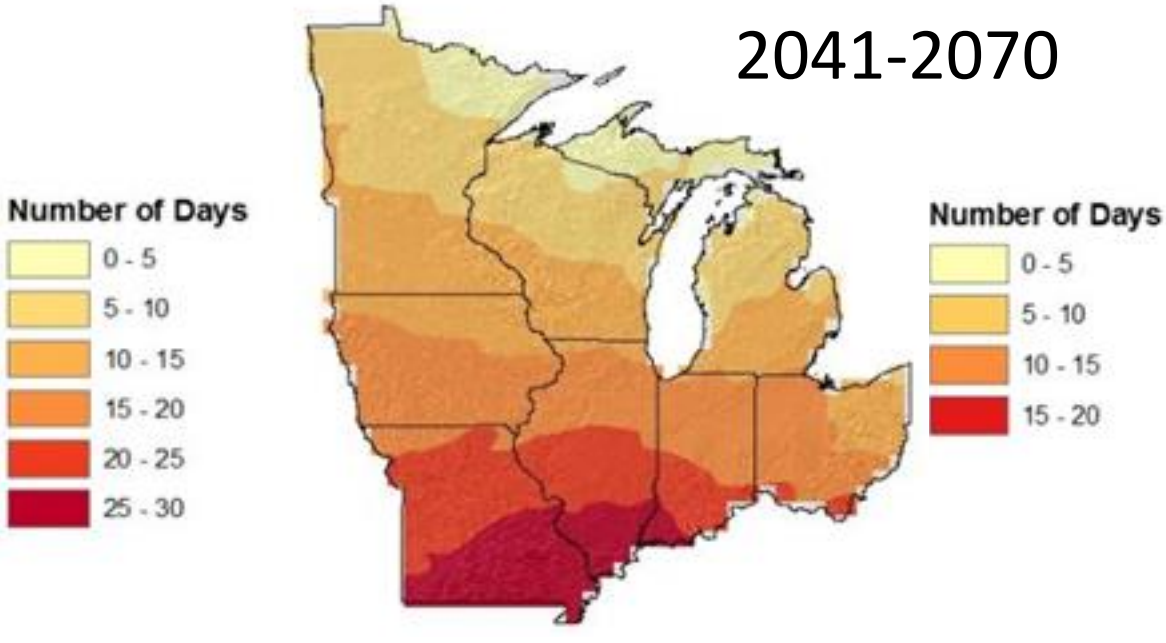
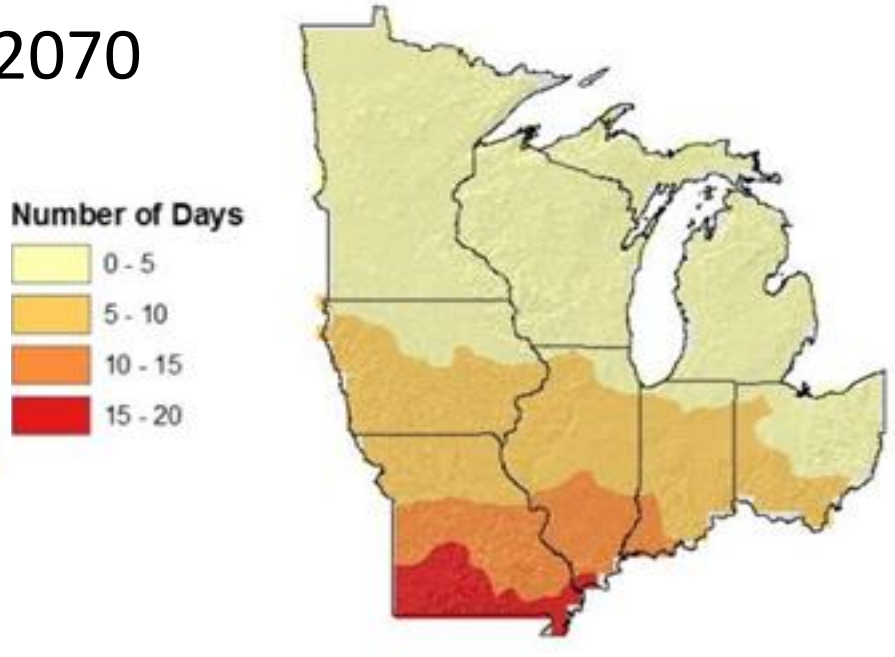
# More Hot Days Anticipated

2041-2070




**Increase in Days > 95°F (35°C)**




**Increase in Consecutive Days > 95°F (35°C)**

Kunkel (2011)

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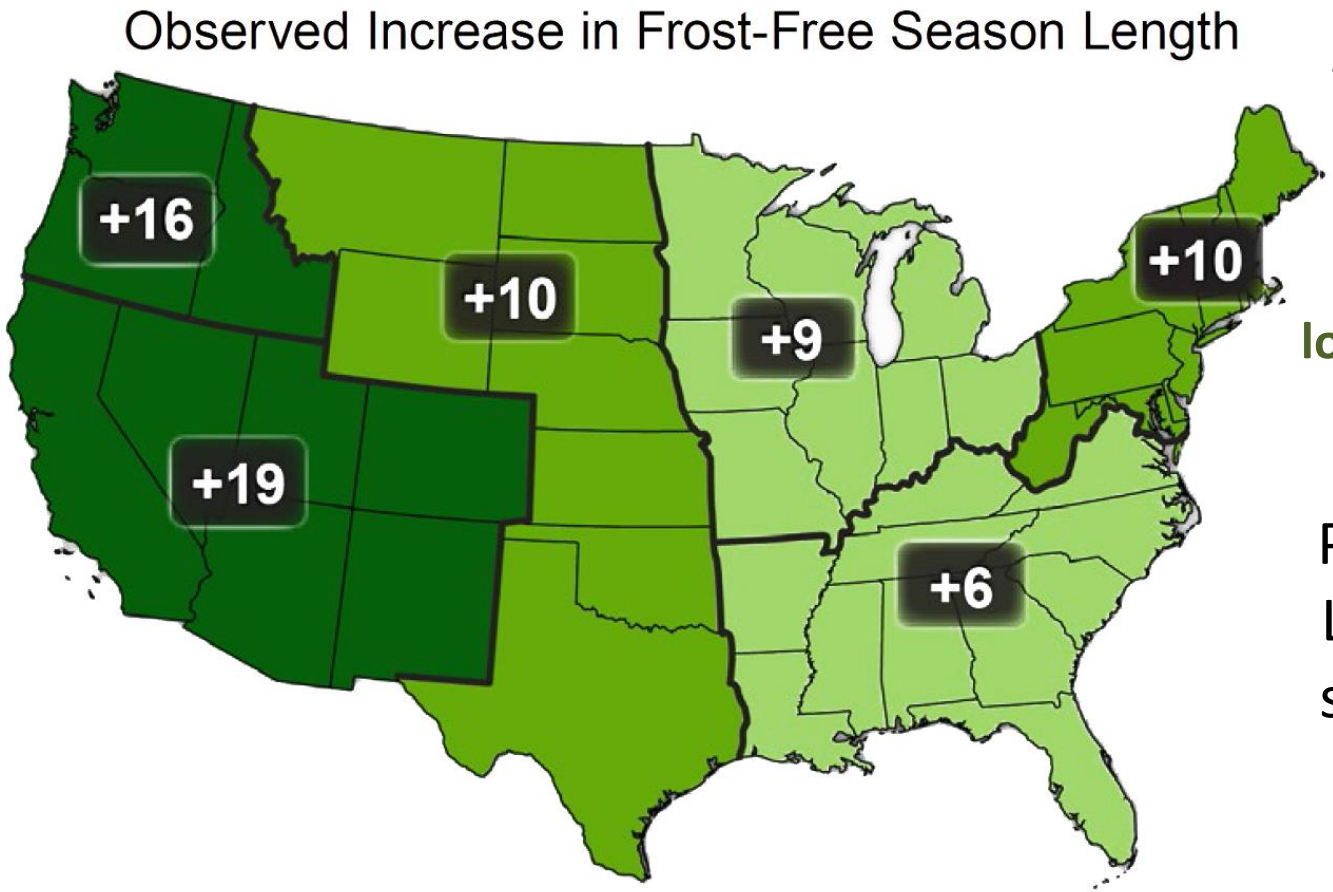
# Longer Frost-free Season




The **frost-free season** has become **9 days longer in the Midwest** and **10 days longer in the Northeast.**

Projected Great Lakes frost-free season in 2100: **~1-2 months longer**

*From the 3rd National Climate Assessment, 2014*

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# The Great Lakes are Warming

Average Great Lakes ice coverage ***declined 71% percent*** from 1973 to 2010

Wang et al., 2012

NASA

- Lake Superior is warming twice as fast as nearby air.
- Winter ice cover is decreasing.
- Lake Superior could have little to no open-lake ice cover during a typical winter within the next 30 years.

Austin and Colman, 2007

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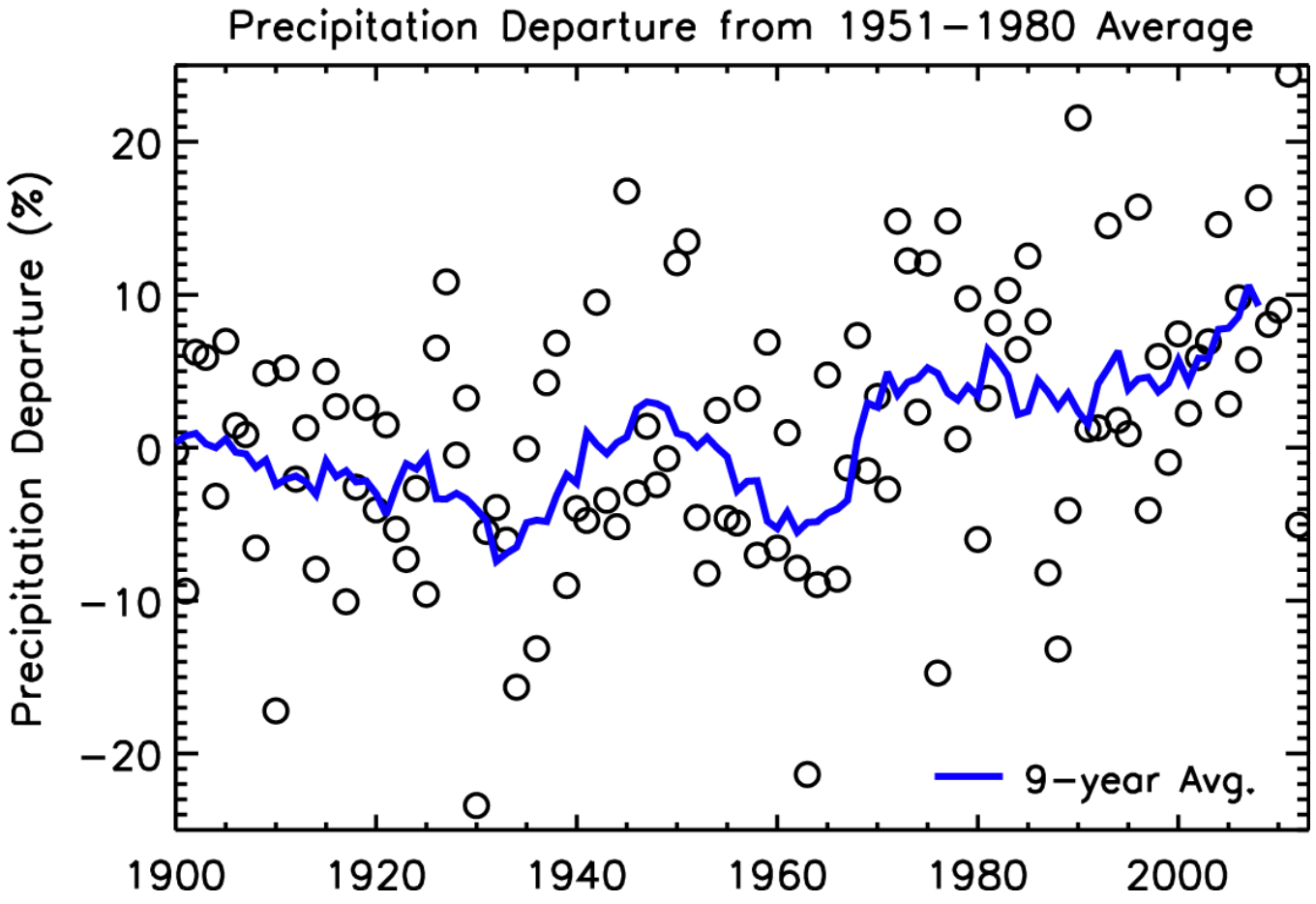
# Observed Regional Precipitation




**11%**

**1900-2012**

Precipitation is variable. Some areas have seen declines while the region overall has seen an increase.

Weighted averages of nClimDiv divisional data from 8 U.S. Great Lakes States.

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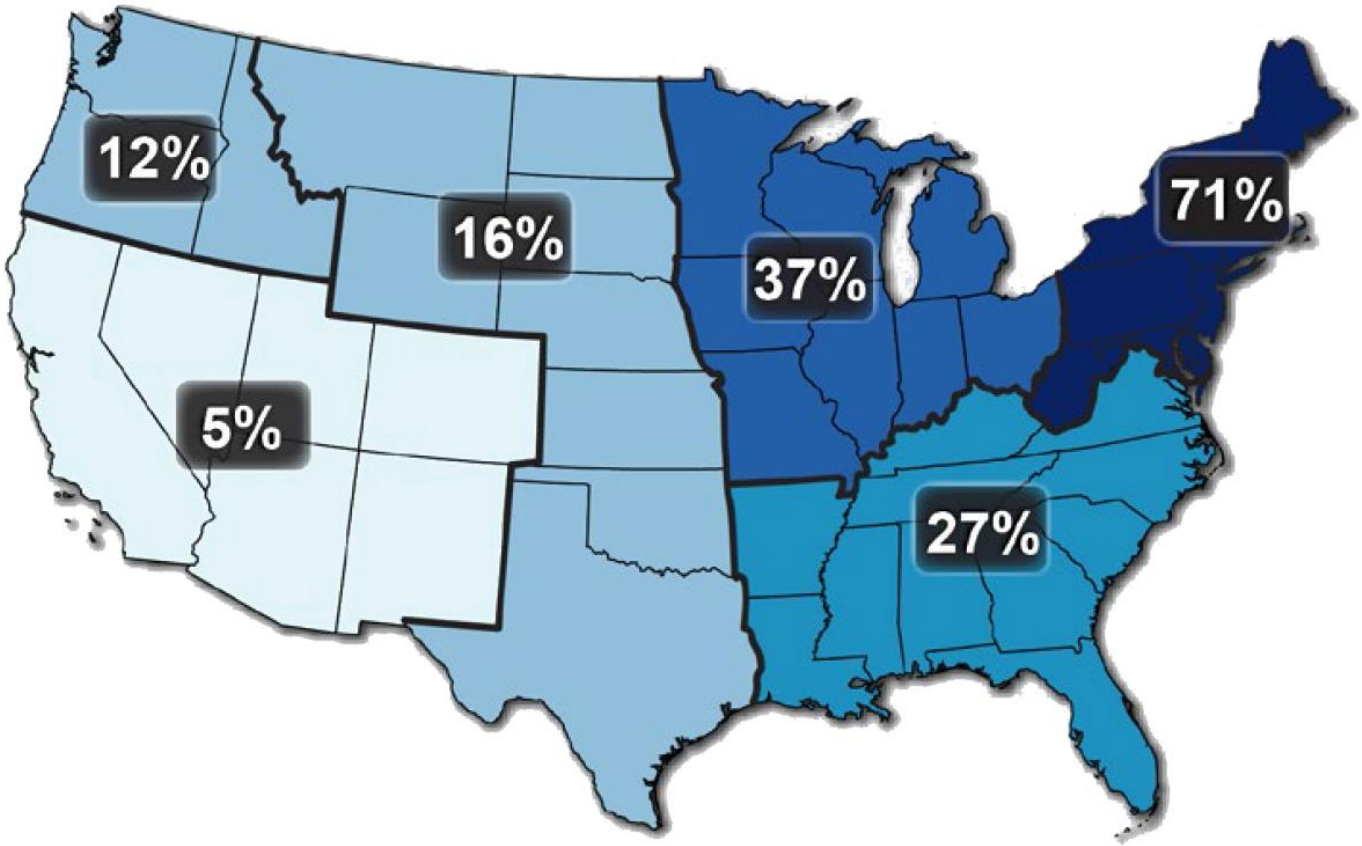
# Observed Extreme Precipitation




**The amount falling in the heaviest 1% of precipitation events increased by 37% in the Midwest and by 71% in the Northeast from 1958 to 2012.**

Following methodology from Groisman et al, 2005, updated.

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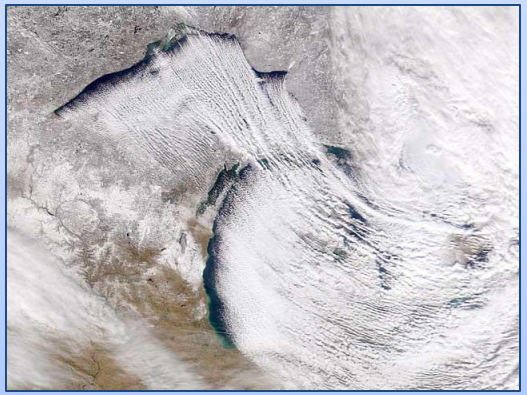
# Changing Precipitation Seasonality

- Shorter winters have lead to more precipitation falling as rain instead of snow.
- Warmer surface temperatures have reduced snow accumulation.



- More lake effect precipitation events have increased snowfall in some areas.

Photo credits: Umich.edu, NASA, weather.com

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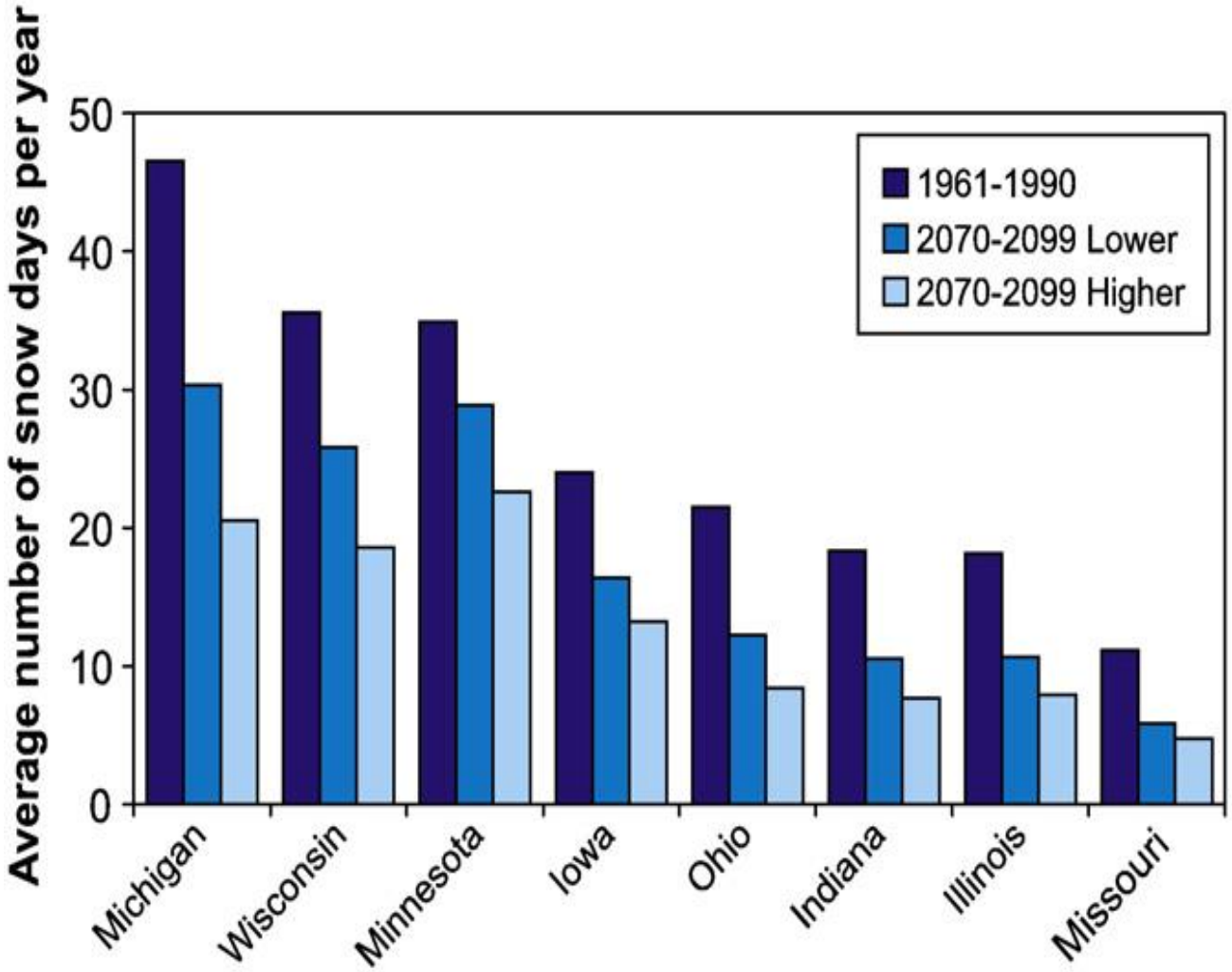
# Projected Snowfall Days




In high emissions scenarios, the number of snow events per year is expected to dramatically decline in Midwestern States by the end of the 21st century.

Hayhoe et al (2010)

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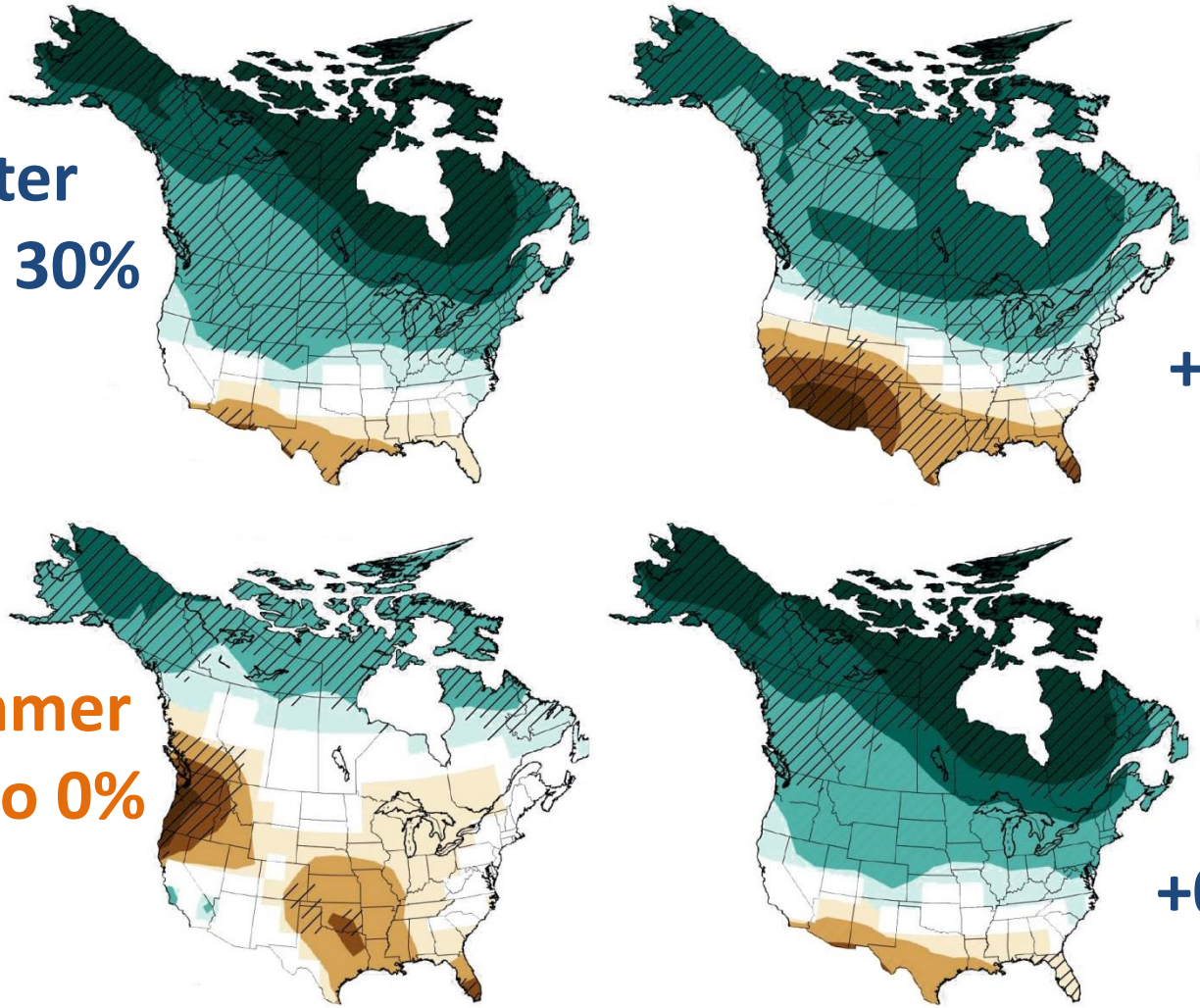
# Projected Precipitation




**Winter**
**+10 to 30%**

***Annual***
***+5 to 20%***

**Spring**
**+0 to +30%**

**Summer**
**-20 to 0%**

**Fall**
**+0 to +30%**

NOAA NCDC / CICS-NC

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# Impacts of Climate Change in the Great Lakes Region

**Changes in temperature and precipitation throughout the region will lead to many impacts in both engineered and natural environments.**

**Water**
**Energy**
**Forests**
**Agriculture**
**Biodiversity**
**Public Health**
**Transportation**
**Fish and Wildlife**
**Tourism and Recreation**

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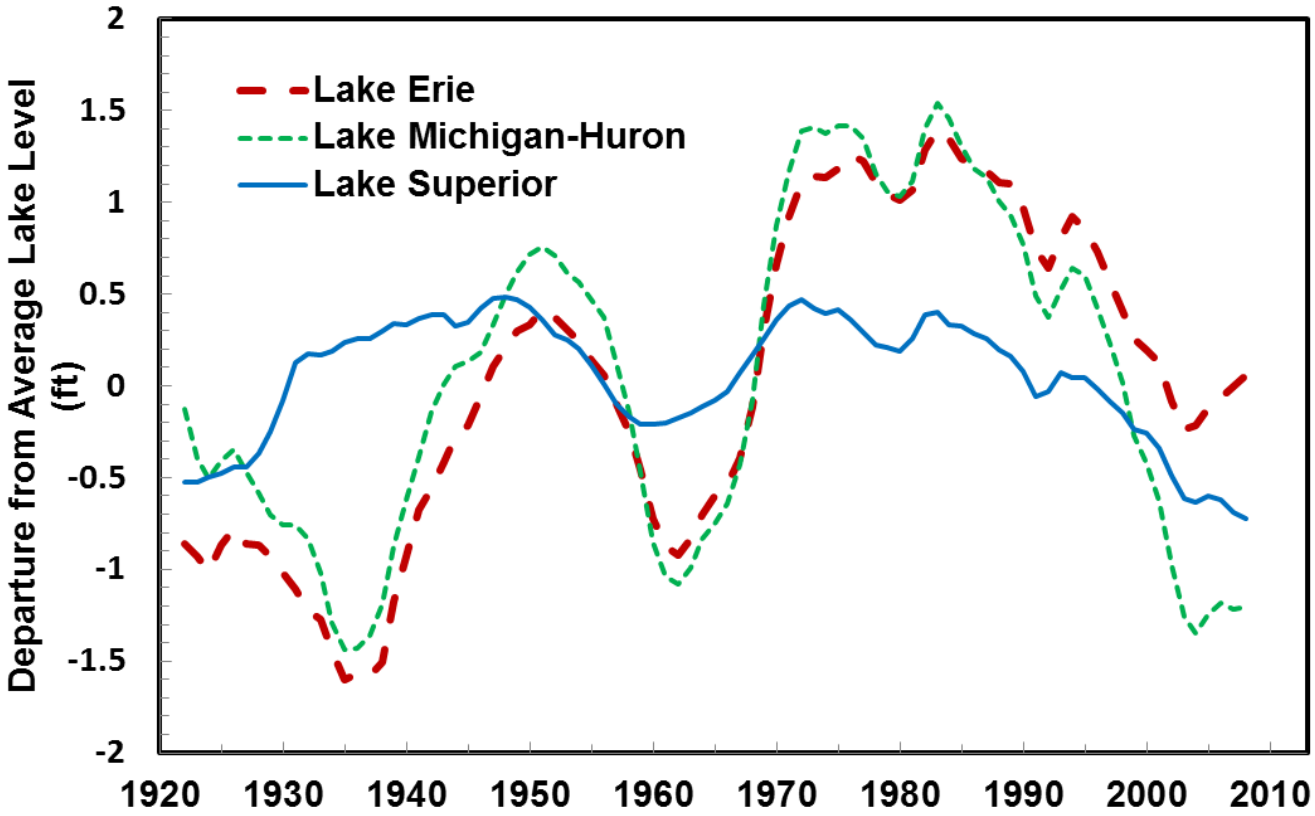
# Lake Levels




Lake levels have declined since reaching record highs in the 1980s.

While most models project continued declines in long-term lake levels, there remains significant uncertainty.

Short-term variability and periods of high lake levels are still anticipated.

GLERL Great Lakes Water Level Dashboard

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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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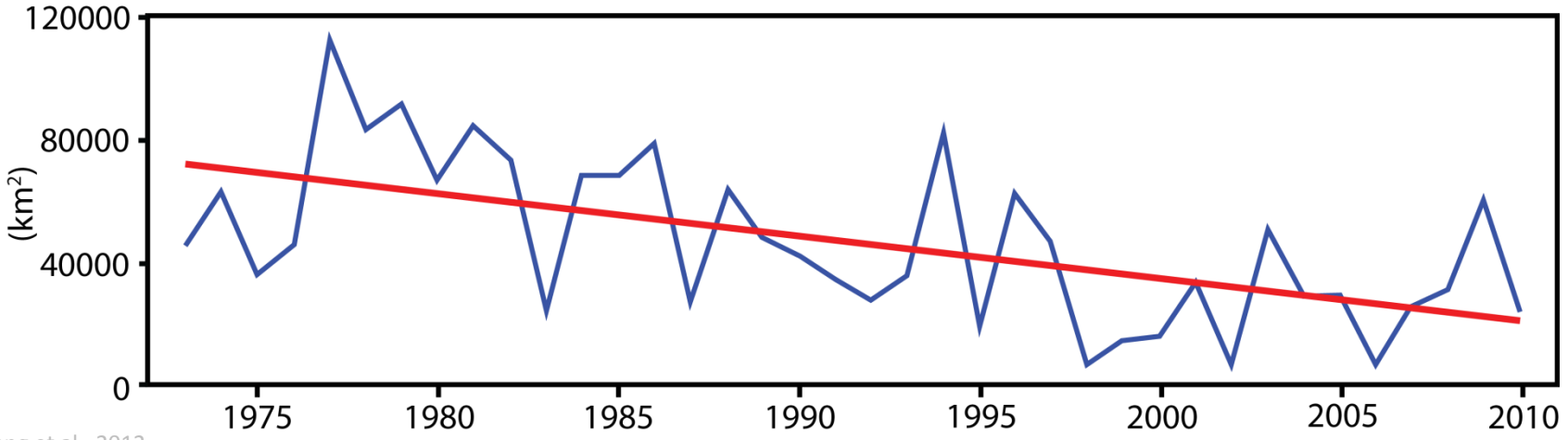
# Impacts of Declining Great Lakes Ice Cover




Wang et al., 2012

- **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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# Flooding and Stormwater

With increased extreme precipitation events, intense, flashy runoff amplify flooding risks.

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# Conspiring Changes: Water Quality

Stronger Storms → More Runoff → Greater Nutrient Loading

Warmer Lake Temperatures → Changed Lake Dynamics → Algal Blooms, Fish Kills

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# Climate Change Impacts on Biodiversity

- Climate change will amplify existing stressors on biodiversity, including sensitivity to land and water use.

- Some species will need to migrate faster relative to other parts of the continent to keep up with the pace of warming. Large agricultural areas and the Great Lakes pose major obstacles to species migration.

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# Learn More

glisa.msu.edu

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GLISA connects users and generators of scientific information to inform adaptation to climate change.

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# How will we adapt?

OHIO SEA GRANT AND STONE LABORATORY

# Do Your PART: A Coastal Storms Preparation, Adaptation, and Response Tool for Great Lakes Marinas

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Sea Grant
Ohio Sea Grant College Program

The Ohio State University

NOAA

# Outline

- Project Summary
- Methodology
- Results
- Overview of Tool

# NOAA Coastal Storms Program (CSP)

NOAA Great Lakes Coastal Storms Program
FOSTERING COMMUNITY RESILIENCE TO COASTAL HAZARDS

- Federal funding from NOAA
- Match provided by Ohio Sea Grant College Program
- Focused on regions throughout the U.S.

**“Development of a Coastal Storms Preparation, Adaptation, and Response Tool for Great Lakes Marinas”**

# Why focus on marinas?

A single marina experienced over $2.7 million in damages from Superstorm Sandy in 2012
(Coast Guard News, November 2012)

Credit: Ohio Sea Grant

# Great Lakes Coastal Infrastructure at Risk

- Currently, only 60 of the 139 federal projects on the Great Lakes support commercial navigation.
- Approximately 80 percent of the Great Lakes harbor structures are older than their 50-year design life and many are more than 100 years old (USACE)

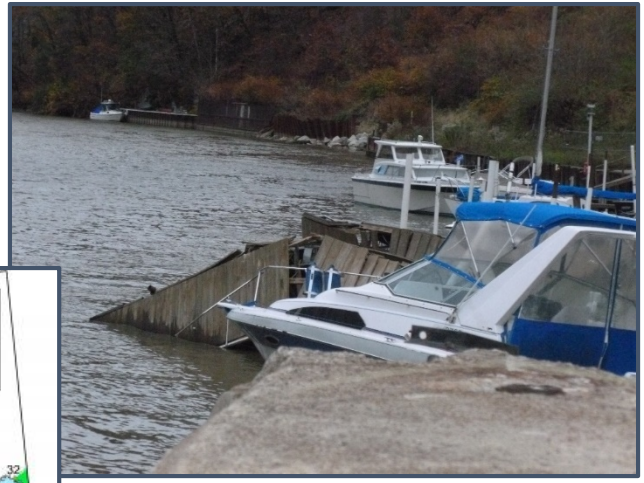
Credit: U.S. Army Corps of Engineers

- Harbor infrastructure maintenance is no longer a federal budget priority
- In addition, recent low water levels have accelerated deterioration in many harbor structures.

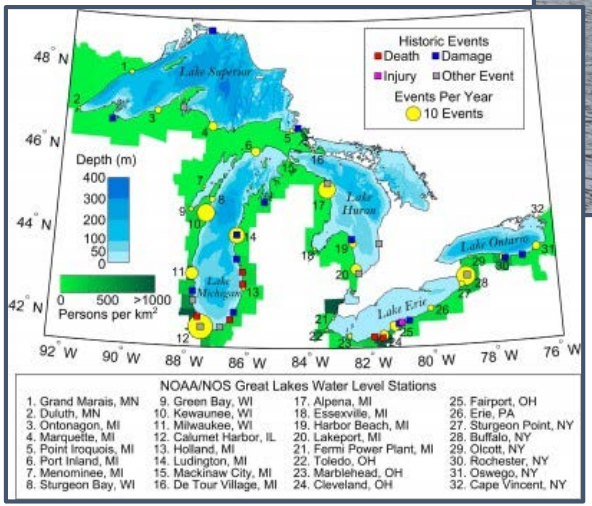
Credit: U.S. Army Corps of Engineers

# Background

- Great Lakes Examples
  - Superstorm Sandy
  - Seiches and Meteotsunamis
  - Flooding
  - Ice
- Why Prepare?



Credit: Ohio Sea Grant




Credit: MSU Extension

# Why focus on Social Science?

Need to Understand:

- **Why** existing tools and resources that could have prevented this situation were not effective
- **How** Great Lakes marinas currently prepare/adapt/respond to storms
- **Where** marinas obtain their information

Credit: ODNR Office of Coastal Management

# Methodology

- Conduct **needs assessment** of marina owners/operators in Erie Pennsylvania, Cleveland Ohio, and Milwaukee
  - Specific impacts associated with coastal storms
  - Current preparedness for coastal storms
  - Barriers to preparation
  - Awareness of existing tools; current sources
  - Types of tools/support desired
- Use focus group data to inform **development of tool** for Great Lakes marinas
- Disseminate tool and coastal storms **education** via workshop and outreach

# Results

- **Impacts associated with coastal storms**
  - Dredging
  - Flooding/debris
  - Abandoned and derelict vessels
  - Lake level changes
  - Structural damage/aging infrastructure
- **Current preparedness for coastal storms**
  - Have an emergency flood plan, but no plan for storms
- **Reasons for lack of preparedness**
  - Weather: tend to overestimate, don't believe forecasters
  - Science: not enough scientific information available to convince them to prepare
  - Priorities: other issues take priority & money

*"Even if we were told by the weatherman, I doubt we would have believed it because they tend to overestimate."*
*Focus Group Participant*

*What kind of information is out there scientifically that says "hey this is what's going to happen?" I mean what do we need from that standpoint as far as, coming up with a plan to try and prepare ourselves for those such events?"*
*Focus Group Participant*

# Results

- **Awareness of existing tools**
  - Little-to-no awareness
- **Sources of information for preparedness and response**
  - Word of mouth
  - Local organizations (fire department, city council, etc.)
  - NOAA
- **Barriers to meeting needs**
  - Money
  - Lack of centralized information
- **Types of tools desired**
  - Case studies
  - Multiple options: webinar/in-person training/workshop
  - Education publications for boaters

> *"All the resources are great, but if you don't attach funding to it they're just something to read for the most part."*
> Focus Group Participant

# Preparation, Adaptation, and Response Tool (**PART**) for Great Lakes Marinas

- **Preparation**

DO THIS NOW

- Coastal Storms Preparation Checklist

- **Adaptation**
  - Coastal Storms Adaptation Checklist

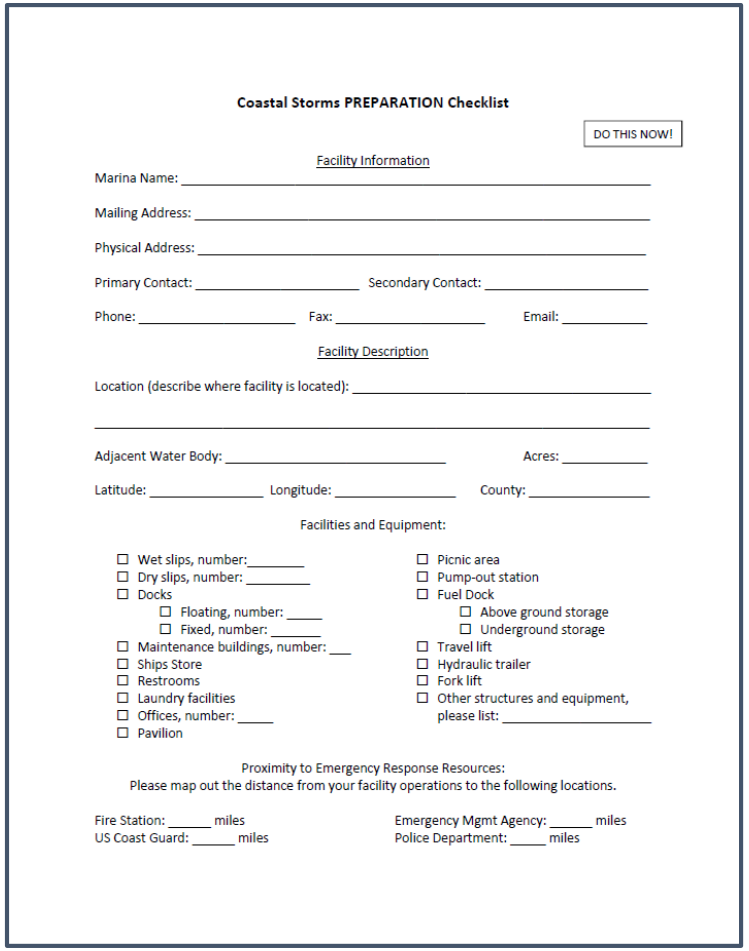
WORK ON THIS

- **Response**
  - Coastal Storms Response Checklist

DO THIS AFTER

# Coastal Storms Checklists

- Preparation – DO THIS NOW
- Adaptation – WORK ON THIS
- Response- DO THIS AFTER
  - Facility Information
  - Team
  - Assess Your Risk



**Coastal Storms PREPARATION Checklist**

DO THIS NOW!

Facility Information

Marina Name: _____

Mailing Address: _____

Physical Address: _____

Primary Contact: _____ Secondary Contact: _____

Phone: _____ Fax: _____ Email: _____

Facility Description

Location (describe where facility is located): _____

_____

Adjacent Water Body: _____ Acres: _____

Latitude: _____ Longitude: _____ County: _____

Facilities and Equipment:

- ☐ Wet slips, number:_____
- ☐ Dry slips, number: _____
- ☐ Docks
  - ☐ Floating, number: _____
  - ☐ Fixed, number: _____
- ☐ Maintenance buildings, number: ___
- ☐ Ships Store
- ☐ Restrooms
- ☐ Laundry facilities
- ☐ Offices, number: _____
- ☐ Pavilion
- ☐ Picnic area
- ☐ Pump-out station
- ☐ Fuel Dock
  - ☐ Above ground storage
  - ☐ Underground storage
- ☐ Travel lift
- ☐ Hydraulic trailer
- ☐ Fork lift
- ☐ Other structures and equipment, please list: _____

Proximity to Emergency Response Resources:
Please map out the distance from your facility operations to the following locations.

Fire Station: _____ miles
US Coast Guard: _____ miles
Emergency Mgmt Agency: _____ miles
Police Department: _____ miles

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# Next Steps

Credit: Ohio Sea Grant

Credit: Ohio Lake Erie Commission

- **Training materials made available**
  - Archived webinar and presentation slides will be posted on Great Lakes Clean Marina Network website: www.glcleanmarina.org
- ***PART* published in print and online**
  - Will be distributed to over 200 marinas through Great Lakes Clean Marina Network
  - Will be made available online through GLCMN
- **Marina case studies**
  - Jill Bartolotta with Ohio Sea Grant completing a second Coastal Storms grant working with marinas in Ohio piloting the PART

# Acknowledgements

- Co-PIs
  - Joe Lucente
  - Dr. Eric Toman
  - Emily Walpole
  - Alexander Heeren
- Marina Owners
- Great Lakes Clean Marina Network
- Project Team
  - Wisconsin Sea Grant
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    - Vicky Harris
    - Todd Breiby
  - Pennsylvania Sea Grant
    - Tom Cermak
    - Sara Stahlman
  - Old Woman Creek National Estuarine Research Reserve
  - Chagrin River Watershed Partners

# Resources for Improving Marina Resiliency in the Great Lakes

# Great Lakes Clean Marina Network Resources

- GLCMN Best Management Practices Guide
- Clean Marina Online Classroom
  - Increasing Resilience
- Increasing Resilience for Marinas and Harbors Project
  - Archived Presentations
  - Project Summary
  - Infrastructure Best Practices
  - Dredging Best Practices
  - Planning and Financing Best Practices
  - Climate Resources

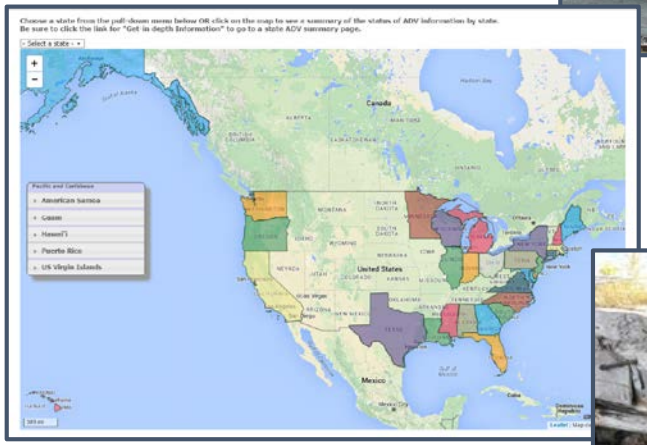
# Technical Assistance

- GLCMN Best Management Practices Guide
- Clean Marina Programs
- Soil and Water Conservation Districts
- Coastal Zone Management Programs
- Sea Grant Programs
- Federal Emergency Management Agency
  - State Emergency Management Agencies
  - Great Lakes Coastal Flood Study
- U.S. Department of Housing and Urban Development
- Small Business Administration

# Topics of Interest

- Dangerous Currents
- Abandoned and Derelict Vessel InfoHub
- Failing Infrastructure
- Nature-Based Shorelines
  - Nature-Based Solutions

Credit: Michigan Sea Grant

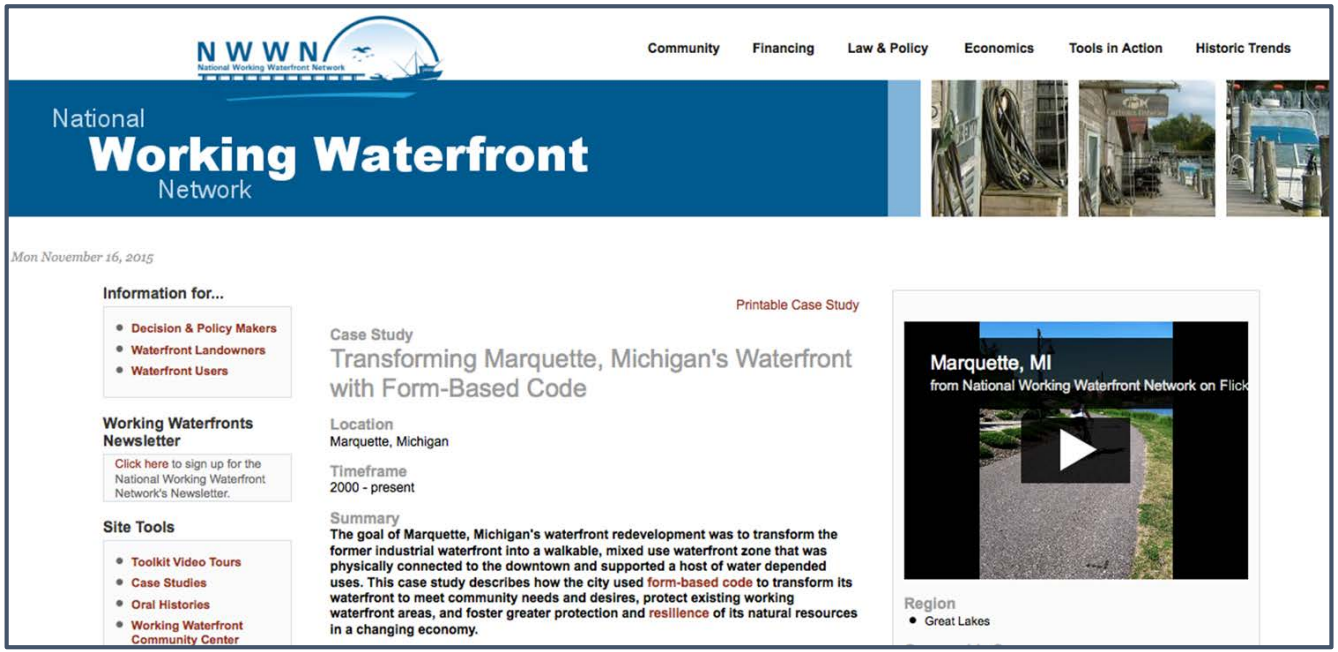


Credit: NOAA Marine Debris Program

Credit: Gene Clark, UW Sea Grant

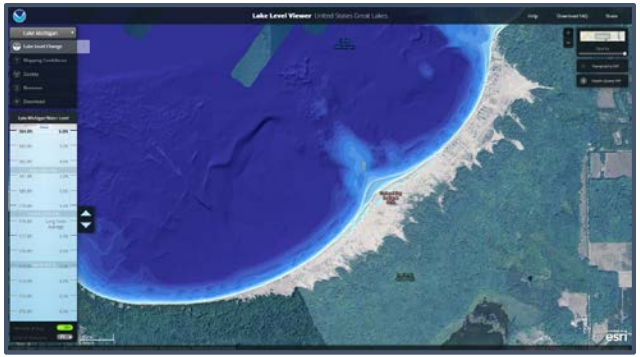
# Sustainable Working Waterfronts Toolkit

- Toolkit
- Tutorials
- Case Studies
- Economics



# NOAA Coastal Resiliency Tools

- NOAA Lake Level Viewer
- NOAA CanVis
  - Tutorial
- NWS Weather-Ready Nation
- Great Lakes Coastal Resilience Planning Guide
- NOAA Great Lakes Water Level Dashboard



Credit: NOAA

Credit: NOAA

# Resources for Boaters

- Boat U.S. – Hurricane Preparation for Boaters
  - Boater's Guide for Preparing for Hurricanes
  - Hurricane Preparation Worksheet
  - What to do after a Hurricane
- U.S. Power Squadrons - Hurricane Preparation for Boaters Course
- NOAA Marine Debris – Storm Season Preparedness
- Great Lakes Observing System Boaters' Forecast Tool
  - User Guide

Credit: Boat U.S. Foundation

# Funding Resources

- NOAA Compiled List of Climate-Related Funding Opportunities
- Great Lakes Coastal Resilience Planning Guide – Funding Opportunities
- Sustainable Working Waterfronts Toolkit – Financing
- NOAA ENOW Explorer

# THANK YOU!

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**Questions?**