CLIMATE CHANGE IN THE GREAT LAKES REGION

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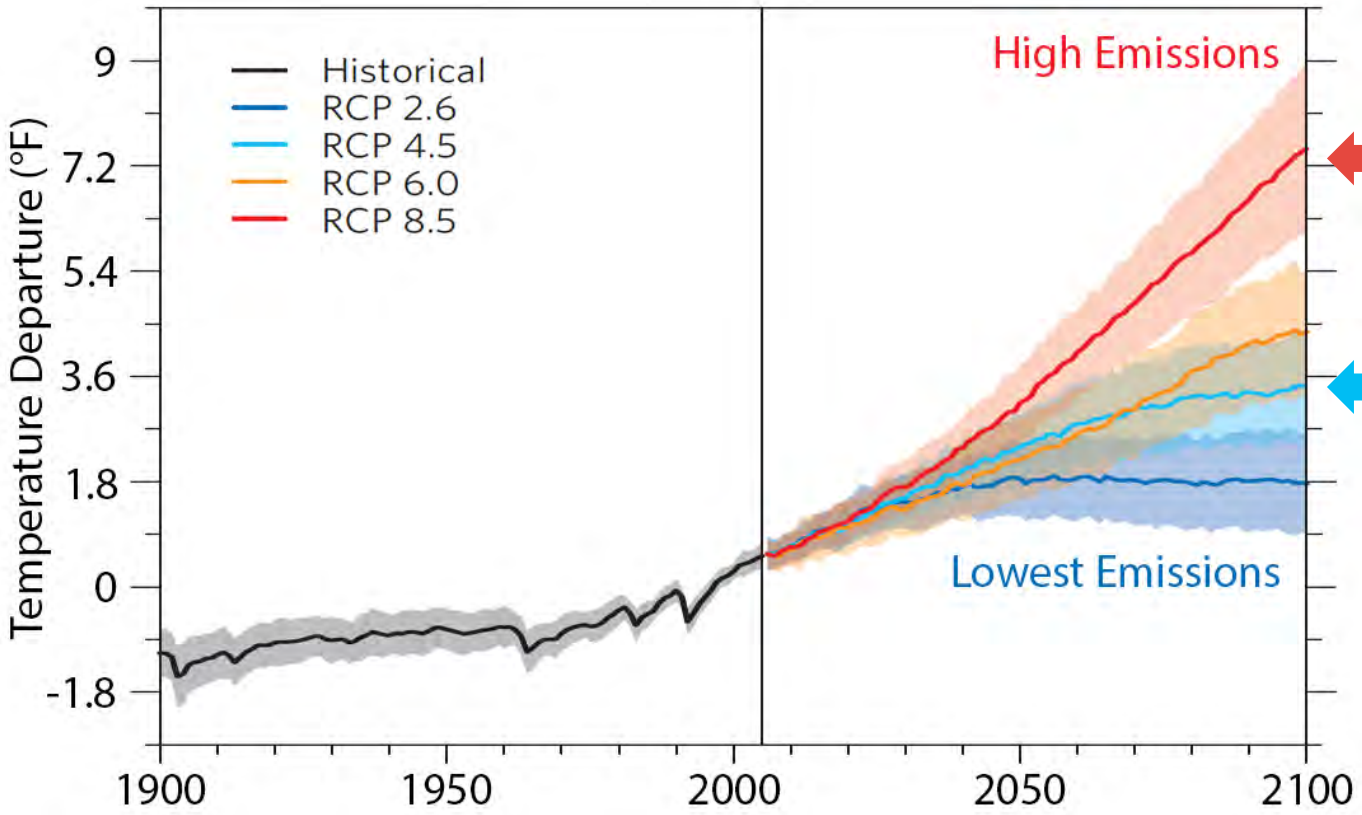
GREAT LAKES INTEGRATED SCIENCES + ASSESSMENTS

UNIVERSITY OF MICHIGAN

Global Temperature



Mean **6.6°F**

Mean **3.5°F**

From Knutti and Sedlacek, 2012

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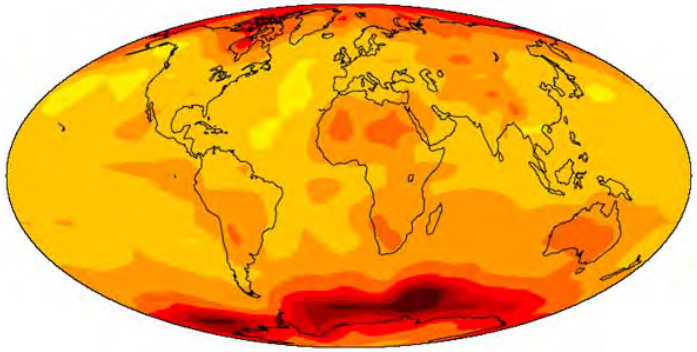
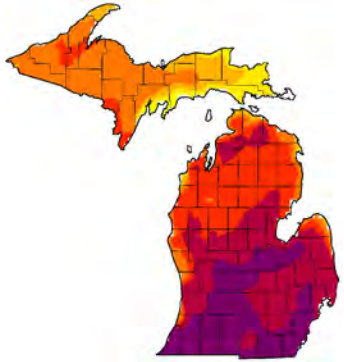
Global, Regional, Local





Global trends are more certain than regional trends

Natural variability plays a larger role at the regional scale

Local land use changes can alter severity of climate impacts

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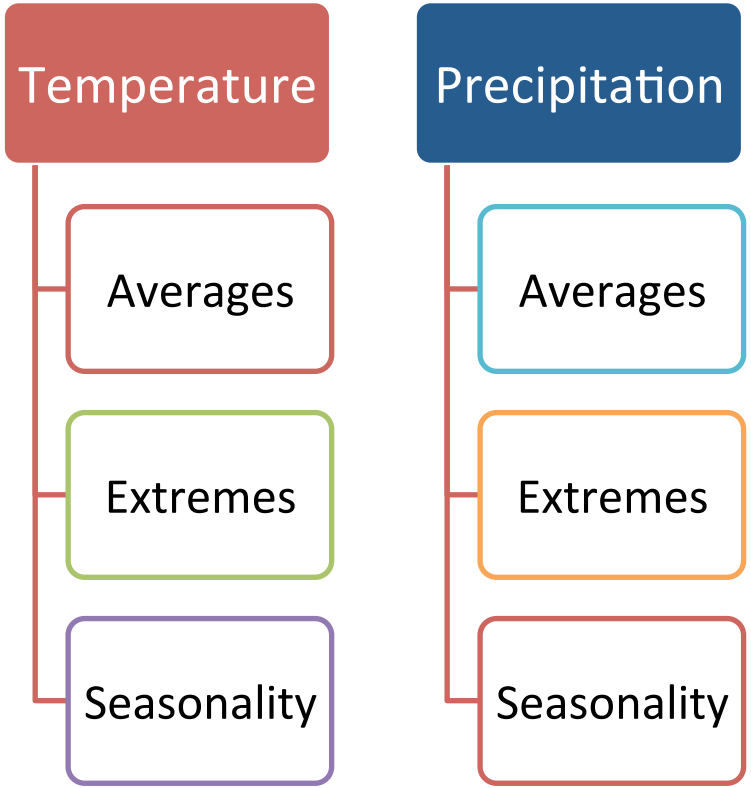
What has Changed?



Changes are often discussed as averages …

… but most environments are managed in terms of timing and extremes.

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Today's Outline

Changing Temperatures

- What has happened
- What is projected
- What are the likely impacts

Changing Precipitation

- What has happened
- What is projected
- What are the likely impacts

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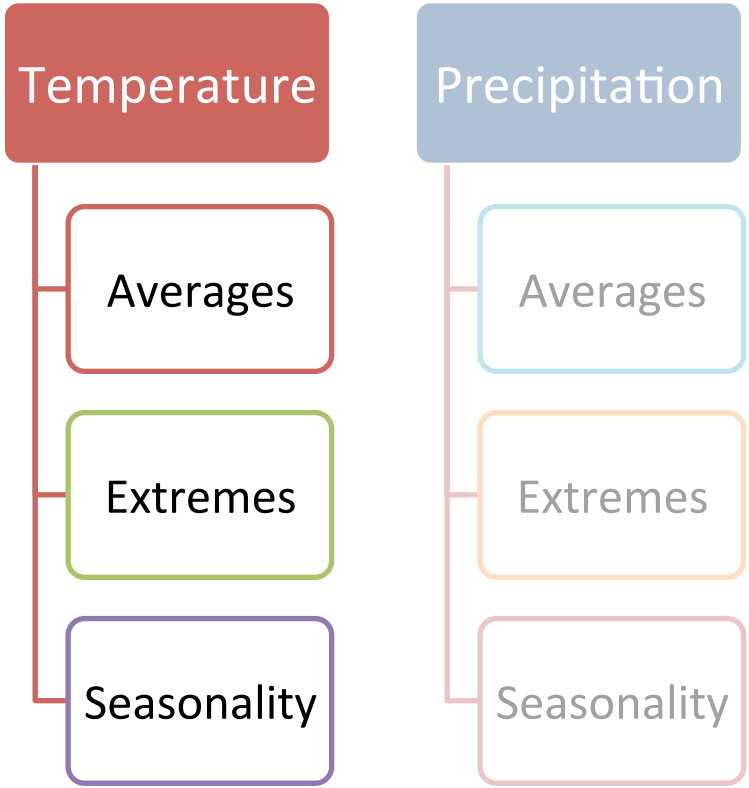
What has Changed?



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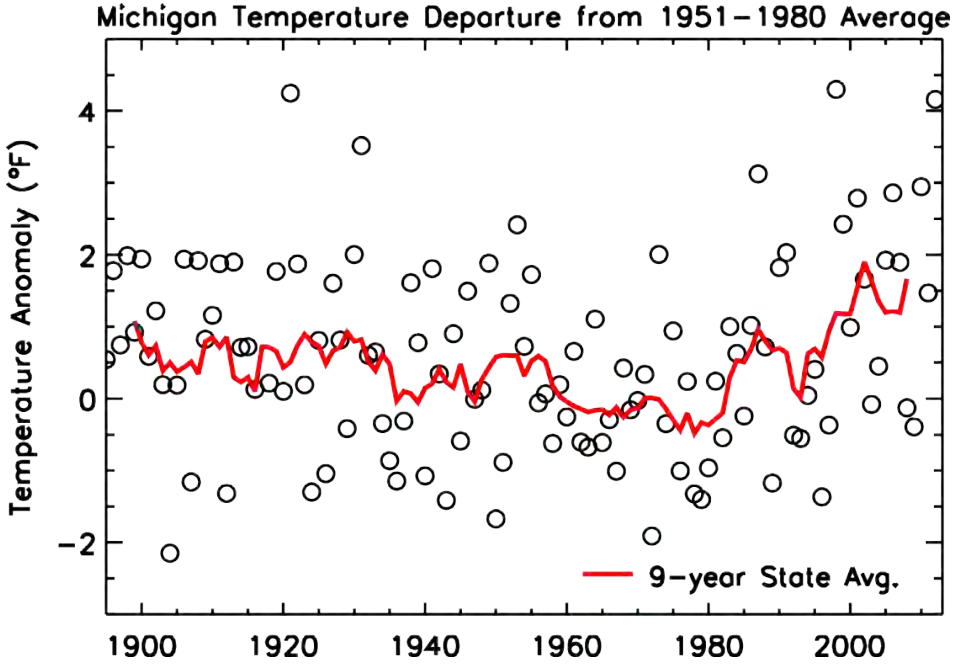
Observed Michigan Temperature



Changes in Average Temperature (°F) from 1951-1980 to 1981-2010	
Annual	0.9
Winter	**1.9**
Spring	1.1
Summer	0.5
Fall	-0.1

Winter temps and overnight lows increased faster than annual averages.

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Observed Heat Waves

Heat waves that pose risks to human health increased in most major Midwestern cities.

Increasing overnight, minimum temperatures increased faster, limiting relief during hot periods.

Observed Change in Number of Harmful Heat Waves

Chicago, IL
1948–2011
(63 years)

Increased 1 per year

Detroit, MI
1959–2011
(52 years)

Increased 2 per year

UCS Heat in the Heartland, 2012

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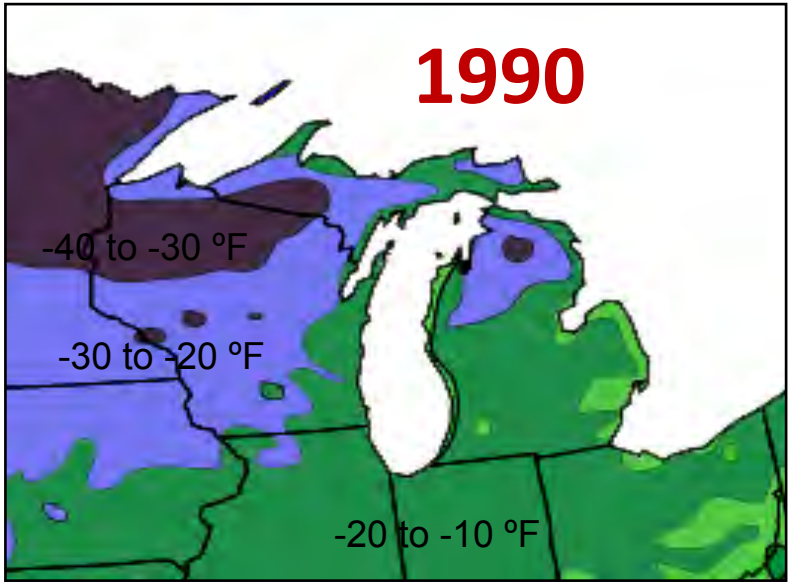
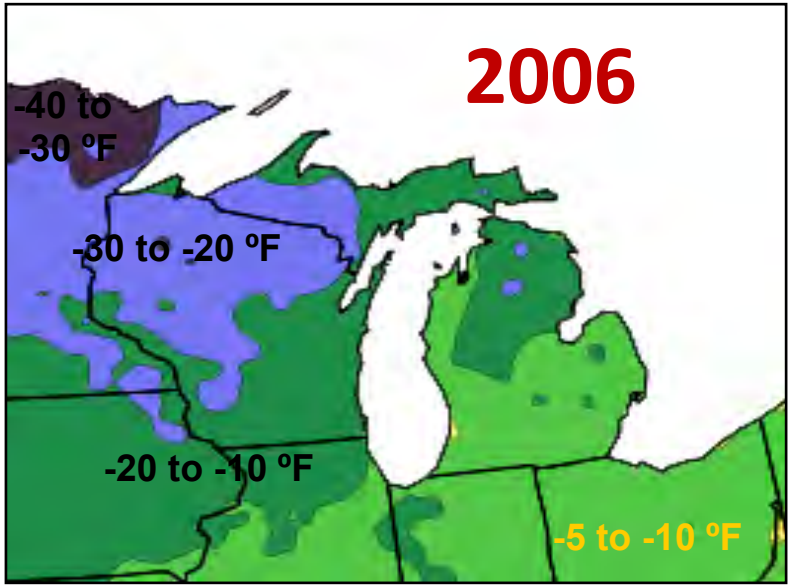
Migrating Plant Hardiness Zones





Average extreme minimum temperatures migrated north.

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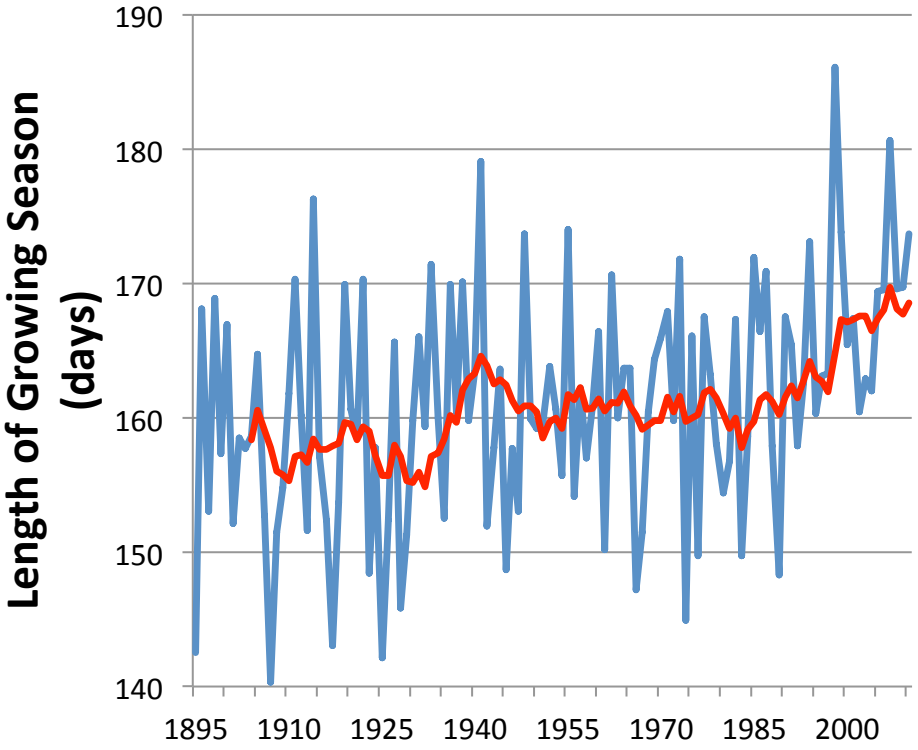
Longer Midwestern Growing Season



Growing season lengthened by ~1-2 weeks

Mostly due to earlier last winter frost in spring

Growing season in 2100 may be 1-2 months longer

Based on data from the National Climatic Data Center for the cooperative observer network and updated from Kunkel et al. (2004)

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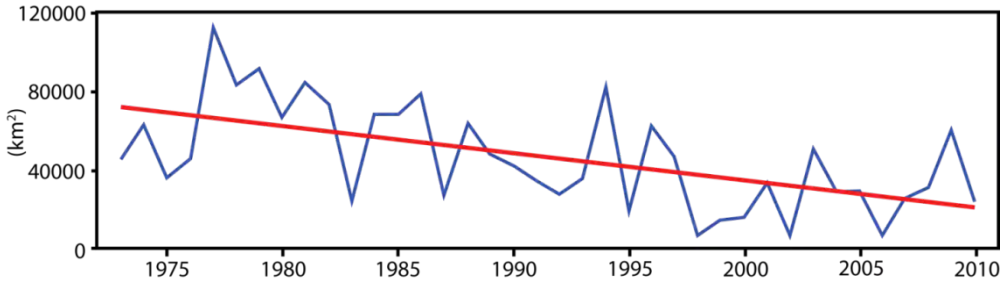
The Great Lakes are Warming

Average Great Lakes ice coverage
declined 71% percent from 1973 to 2010 Wang et al., 2012



Lake Superior water is warming twice as fast as air

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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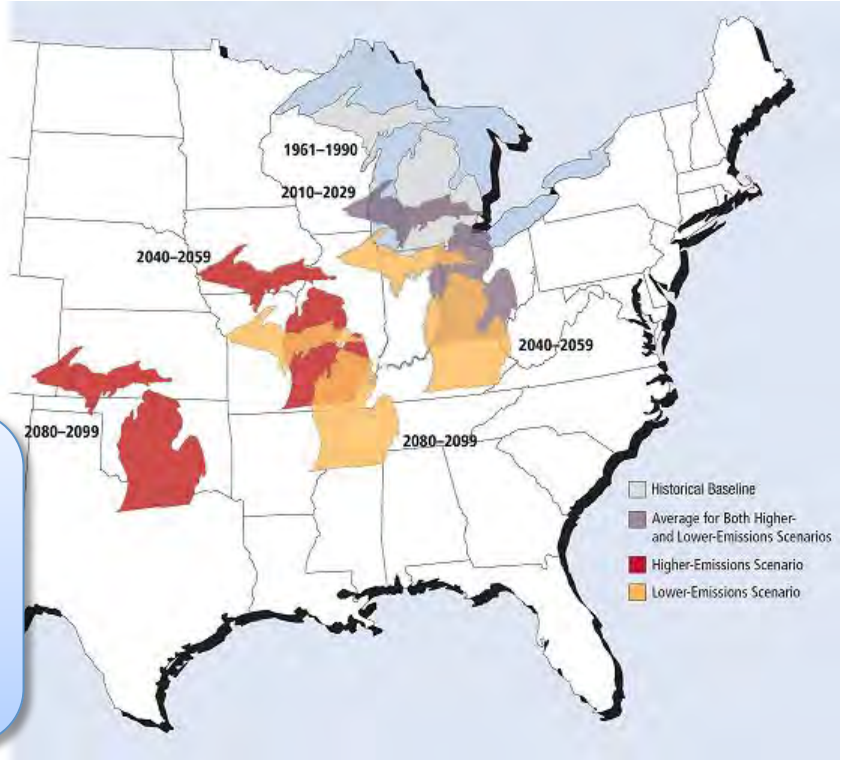
Projection: A Migrating Climate

Future generations will experience a fundamentally different climate.

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



Courtesy UCS 2009, original work by Hayhoe et al.

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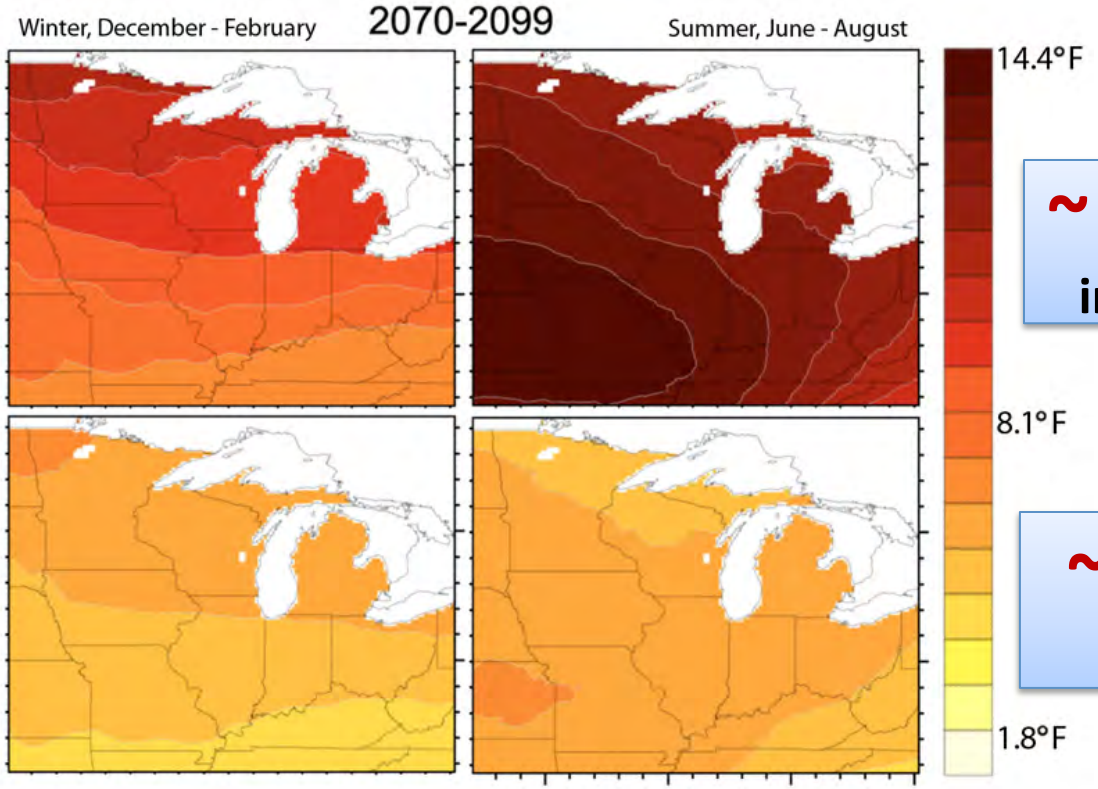
Projected Midwest Temperature Increases

High Emissions Scenario

Low Emissions Scenario



~ 9-12°F Rise
in A1F1 Scenarios

~ 4-7°F Rise
in B1 Scenarios

Modified from Hayhoe et al, 2010

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Impacts in the Great Lakes Region

Changes in temperature and precipitation will impact both engineered and natural environments.

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

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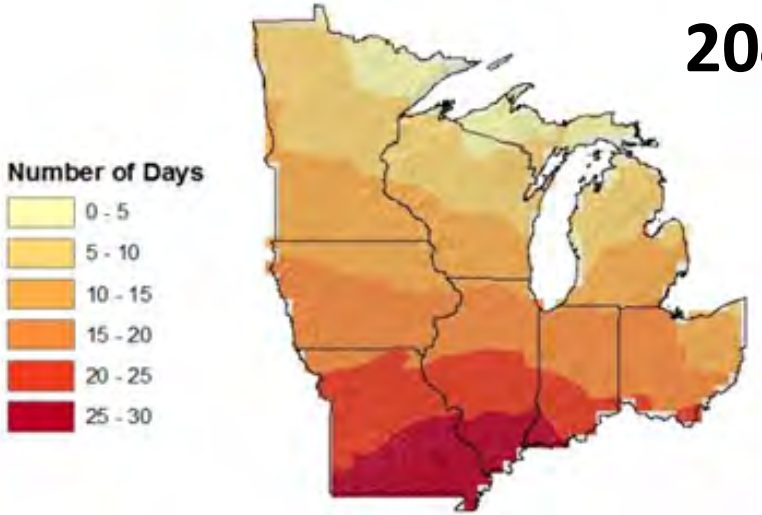
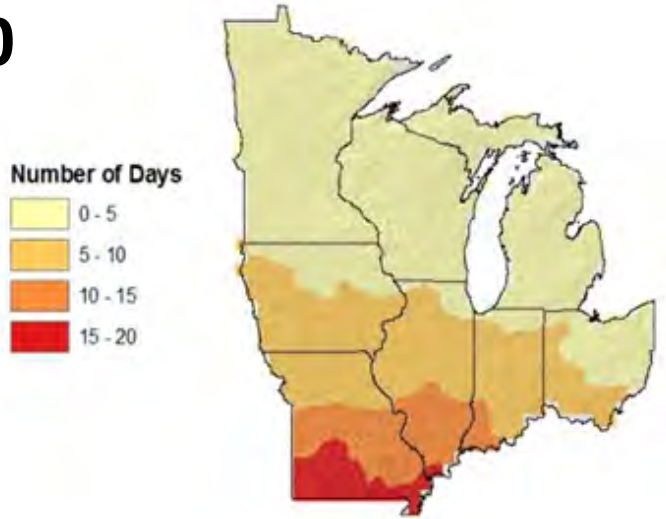
More Hot Days Projected

2041-2070



Increase in Days > 95°F



Increase in Consecutive Days > 95°F

Kunkel (2011)

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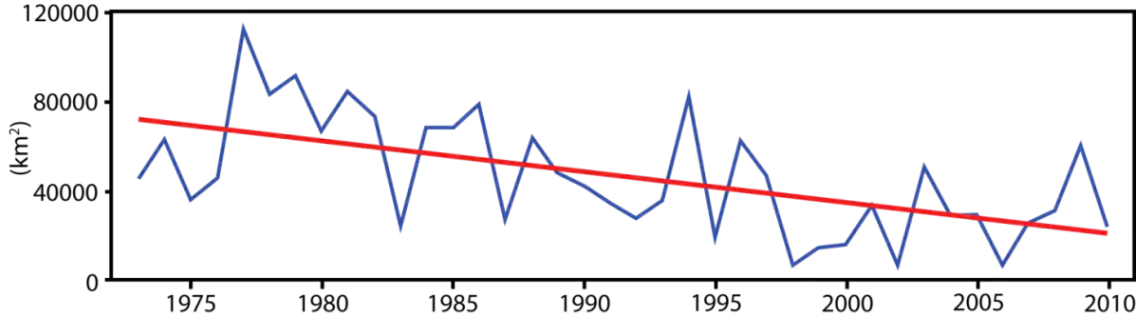
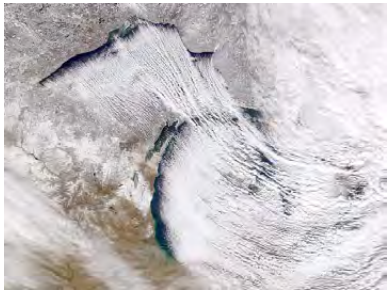
Impacts of Declining Lake Ice Cover





Wang et al., 2012

- **Fishing Industry:** Harms whitefish spawning areas and increased wetland
- **Coastal Zone:** Loss of stable platform for recreation
- **Navigation:** Potentially lower water levels; lengthened shipping season

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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 also allows for a longer shipping season

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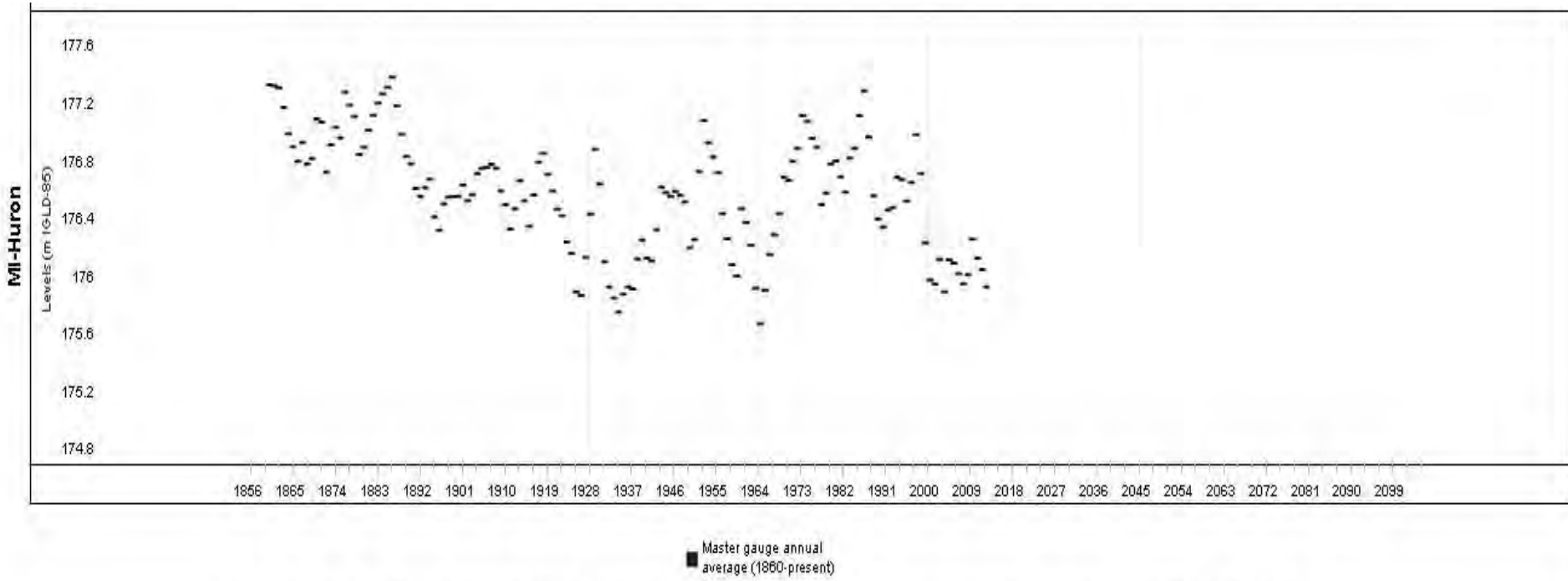
Lake Level Projections



Drew Gronewold, NOAA/GLERL

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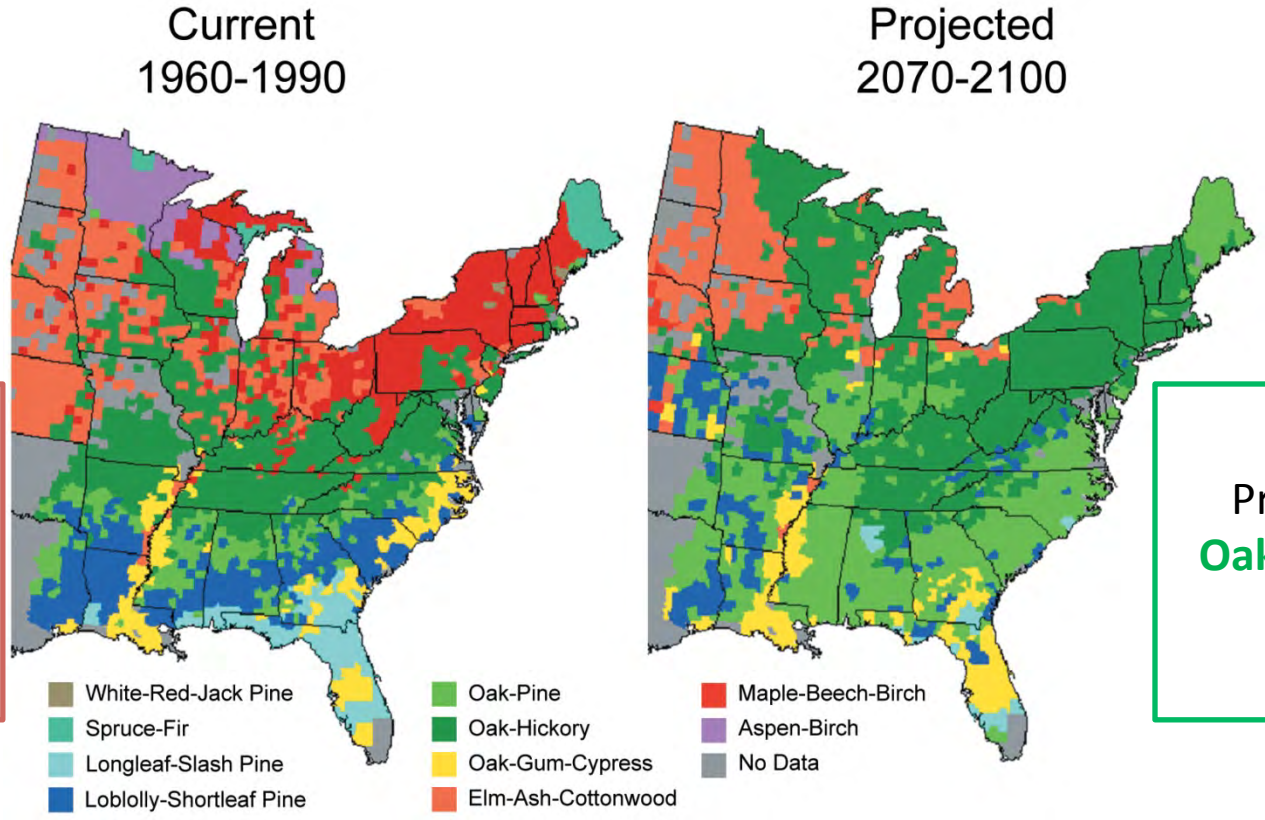
Projected Shifts in Forest Types



Current:
Maple, Beech, Birch, and Aspen

Projected:
Oak, Hickory, Elm

USGCRP (2009)

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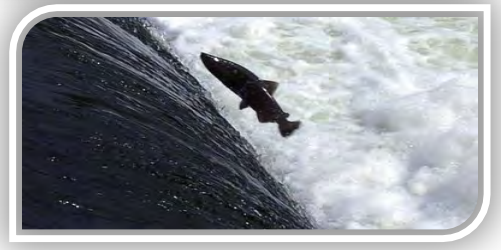
Impacts on Biodiversity

- Amplified existing stressors, including sensitivity to land and water use
- Some species will need to migrate to keep up with the pace of warming …

  … but, large agricultural areas and the Great Lakes are major obstacles to migration



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Impacts on Agriculture

- Some crops may benefit in the near future from increasing carbon dioxide concentrations until negated by warmer temperatures.

- Perennial crops may be more vulnerable to the pace of climate change and may face greater adaptation challenges.

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Agriculture Vulnerabilities: Spring 2012 Cherry Crops

- The early warming was extreme weather event
- The seasonal warming fits a pattern of a more variable climate

- The early warming followed by a normal hard freeze was devastating to cherry buds
- **$92 million loss** from tart cherries alone

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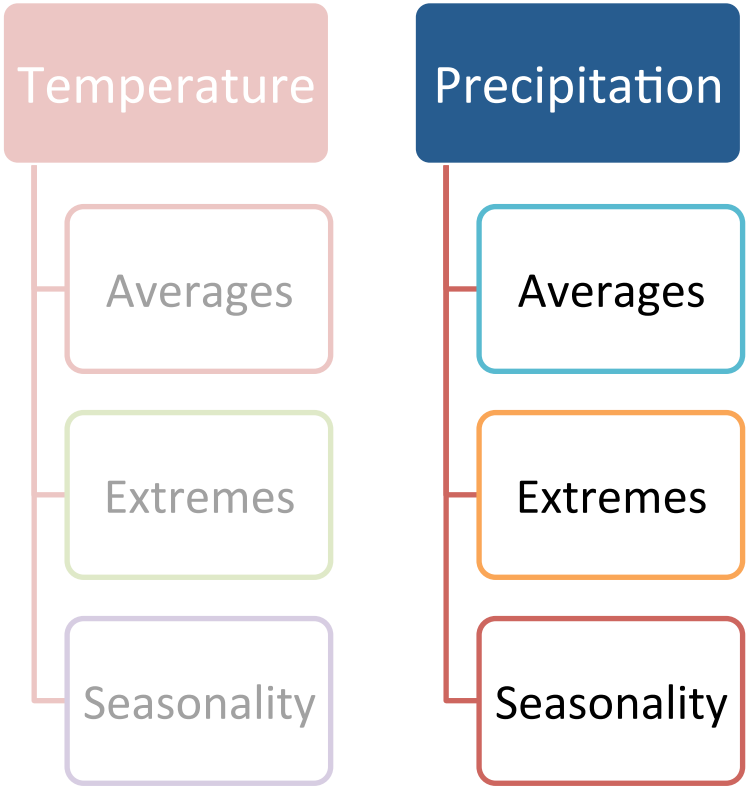
What has Changed?



Changes are often discussed as averages …

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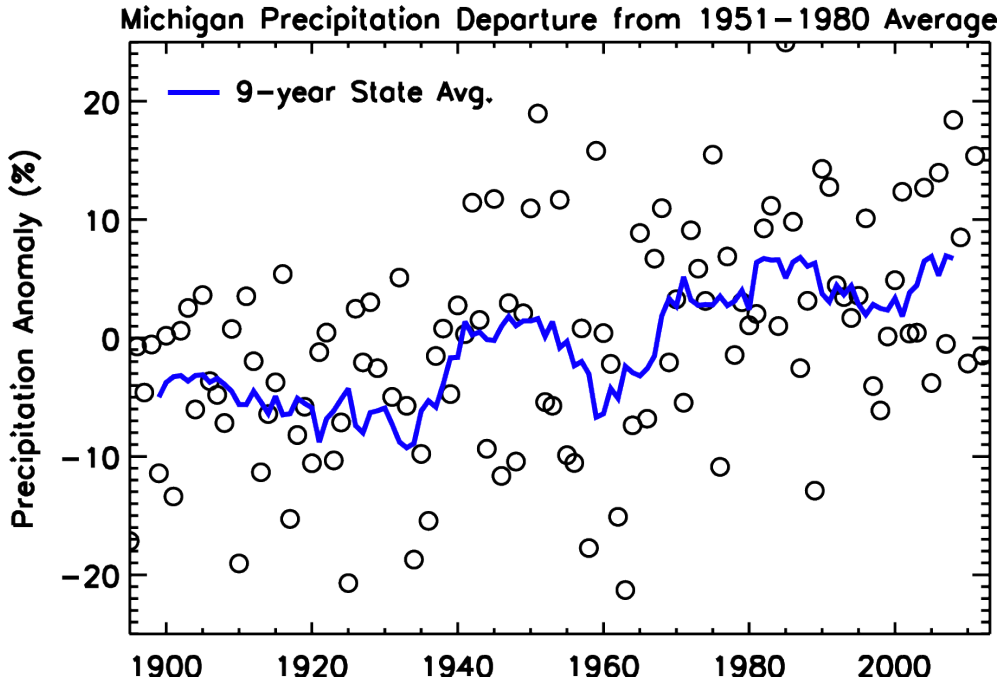
Observed Michigan Precipitation



Changes in Total Precipitation (%) from 1951-1980 to 1981-2010	
Annual	5.0
Winter	5.6
Spring	1.3
Summer	-1.0
Fall	15.8

Precipitation increased in Winter and Fall but remained stable or have declined during Spring and Summer.

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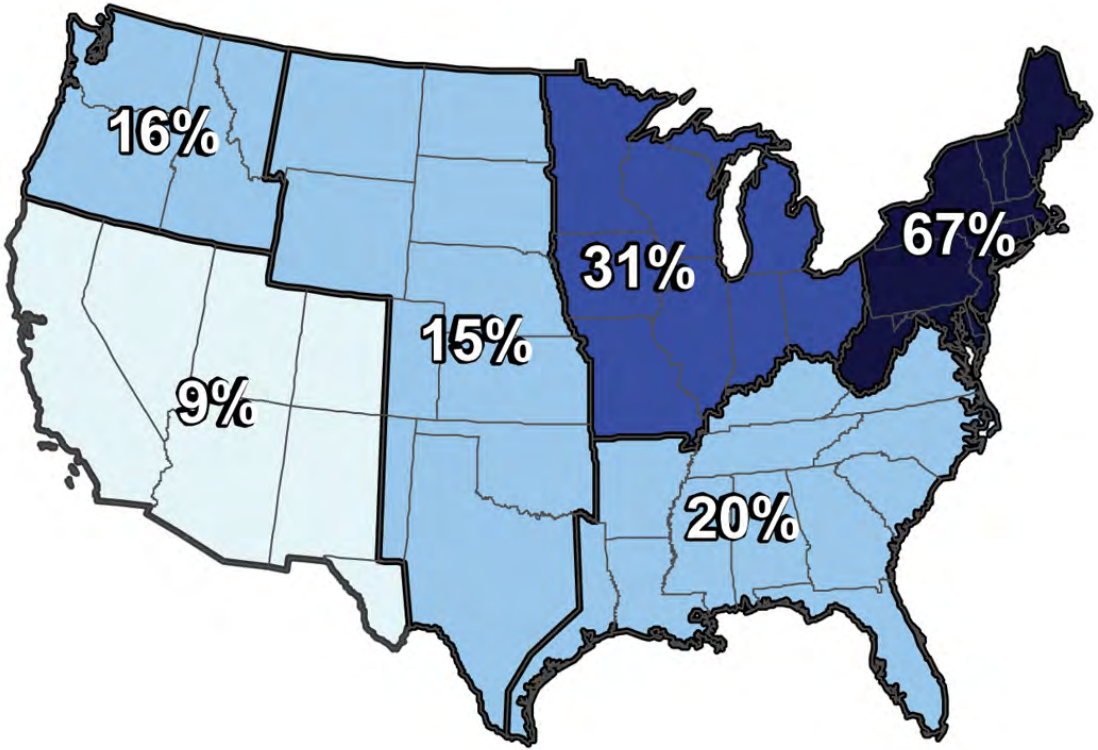
Observed Extreme Precipitation Intensity



Intensity **of the heaviest 1% of precipitation events increased from 1958 to 2007.**

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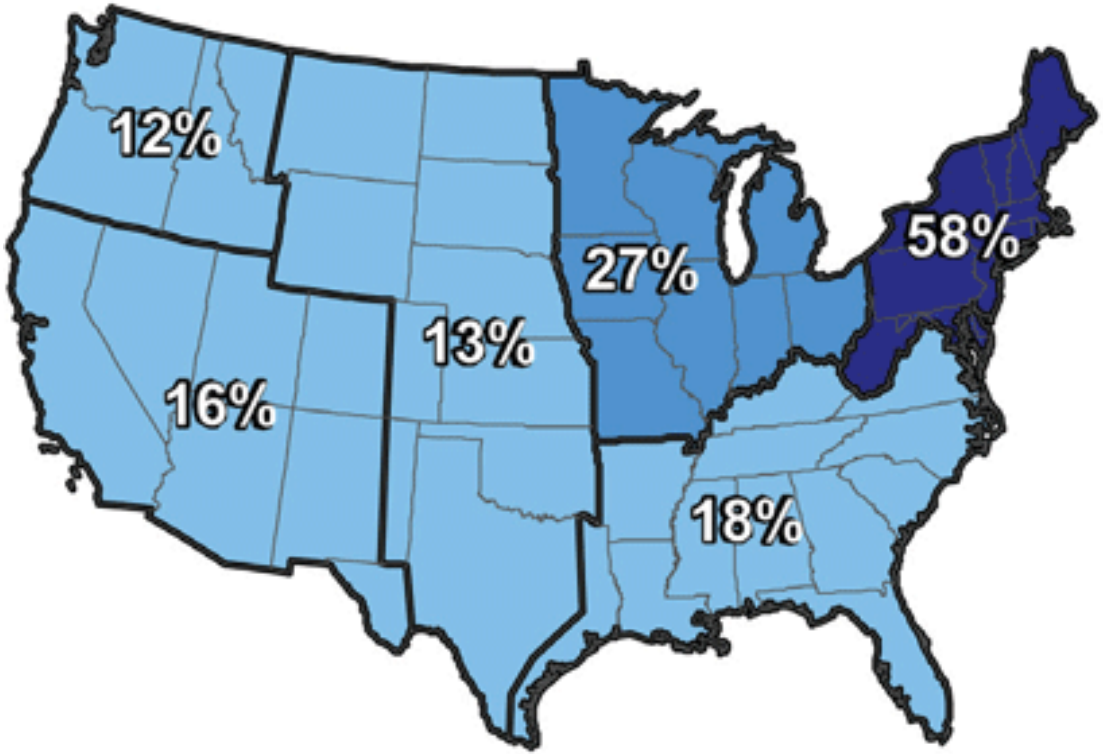
Observed Extreme Precipitation Frequency



Frequency **of heaviest 1% of precipitation events increased from 1958 to 2007.**

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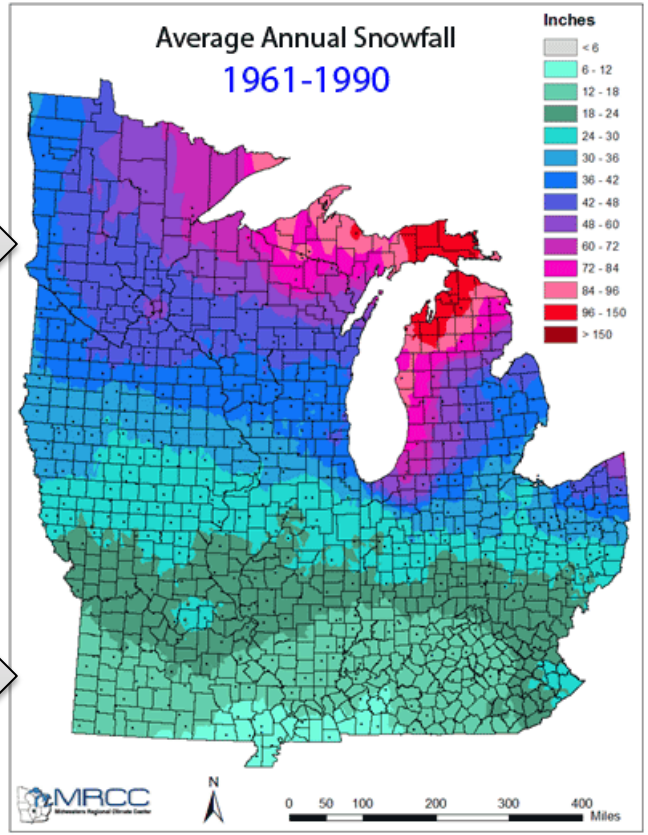
Observed Snowfall Change

More in Northern Lake Areas

Less in Southern Areas



Snowfall increased in the North & decreased in the South

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Changing Winter Precipitation

- Lake effect snow increased in some areas.
- But, shorter winters led to more falling as rain.
- Warmer surface temperatures also reduced snow accumulation.

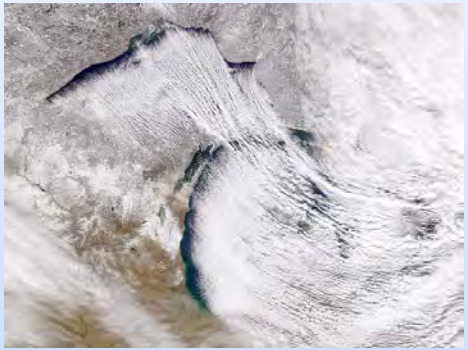

Photo credits: Umich.edu, NASA, weather.com

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Projected Precipitation

2041-2070 vs. 1971-2000

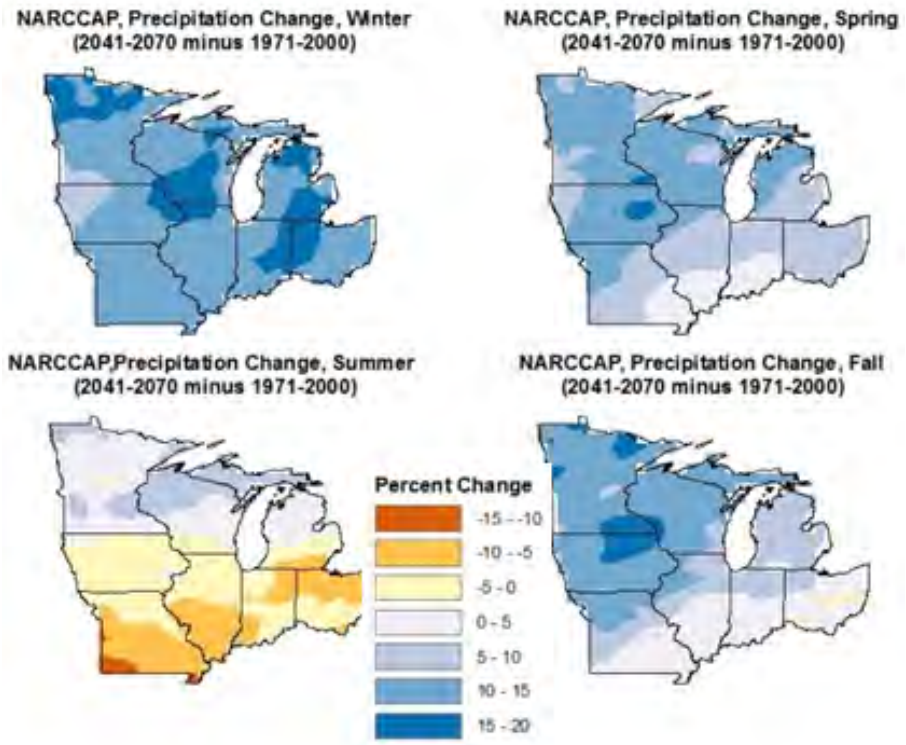
Annual
+5 to 15%

Winter
+5 to 20%

Spring
+0 to 20%

Summer
+10 to -10%

Fall
+0 to 20%



Kunkel (2011)

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Impacts in the Great Lakes Region

Changes in temperature and precipitation will impact both engineered and natural environments.

Fish
Water
Energy
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Transportation
Birds and Wildlife
Tourism and Recreation

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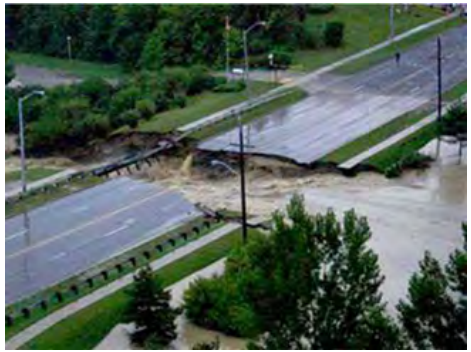
Flooding and Stormwater

Stronger and more frequent extreme events amplify flood risks.



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Impacts on Agriculture

- Increasing intensity of severe storms increases the risk of runoff and erosion.

- Shifts in the timing of precipitation will affect field preparation time in spring.

- Some crops may benefit in the near future from increasing carbon dioxide concentrations until negated by warmer temperatures.

- Perennial crops may be more vulnerable to the pace of climate change and may face greater adaptation challenges.

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Conspiring Changes: Water Quality

Stronger Storms → More Runoff → Greater Nutrient Loading

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

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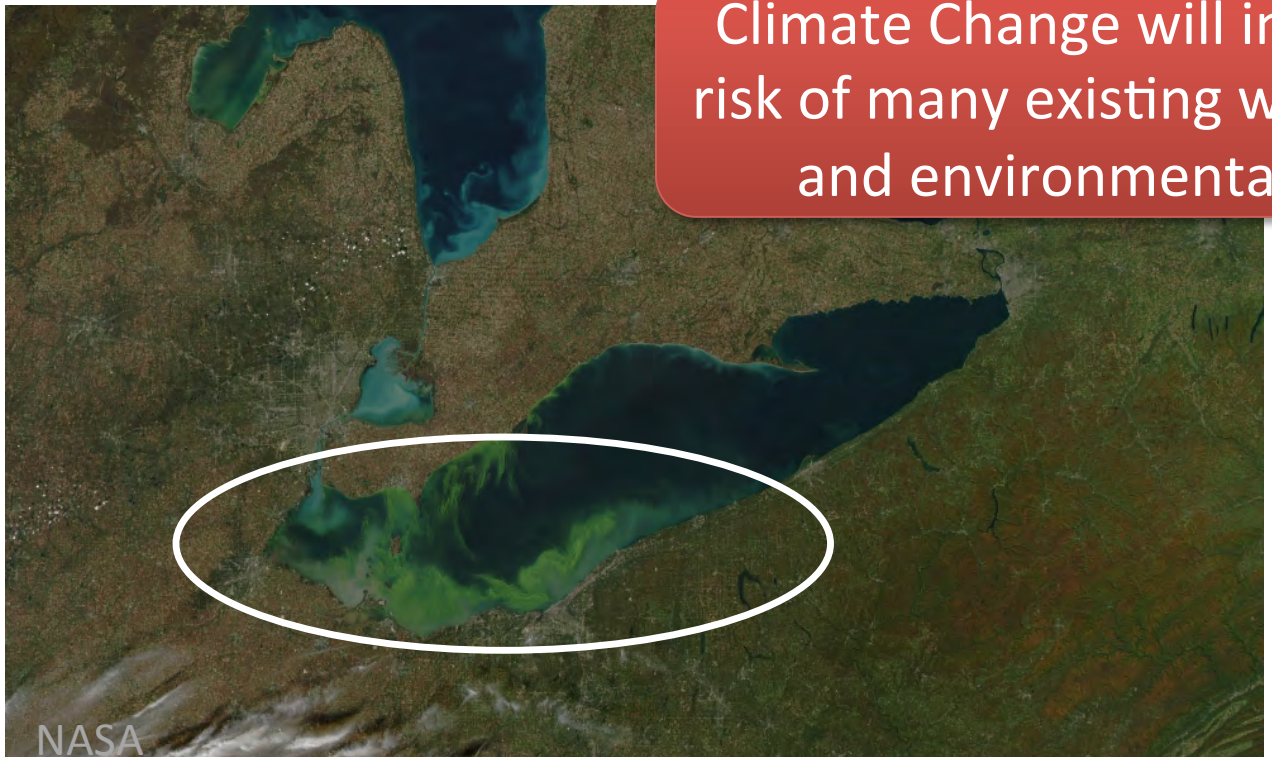
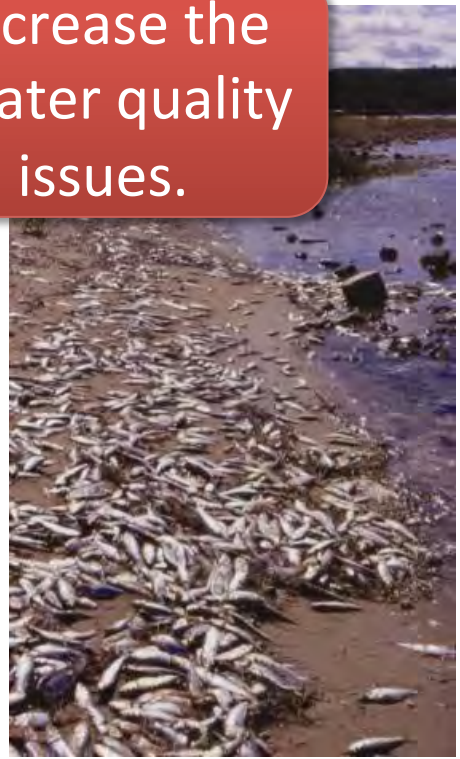
Algal Blooms and Fish Kills

Climate Change will increase the risk of many existing water quality and environmental issues.





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How will we adapt?

Winter is a part of our "Sense of Place".
We are losing Winter as we once knew it.
-John Magnuson

Are we preparing to adapt?

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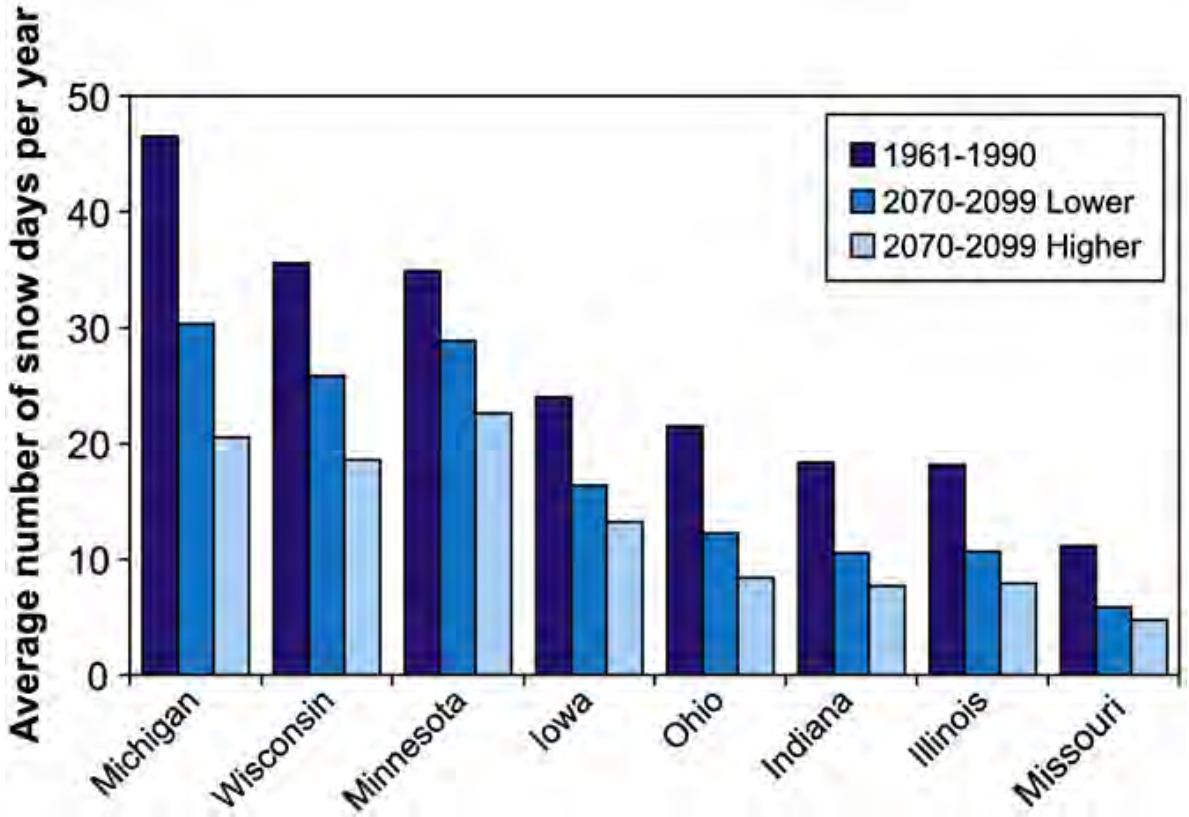
Extra Slides

Projected Snowfall Days



Hayhoe et al (2010)

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