

# Climate Change in the Great Lakes Region



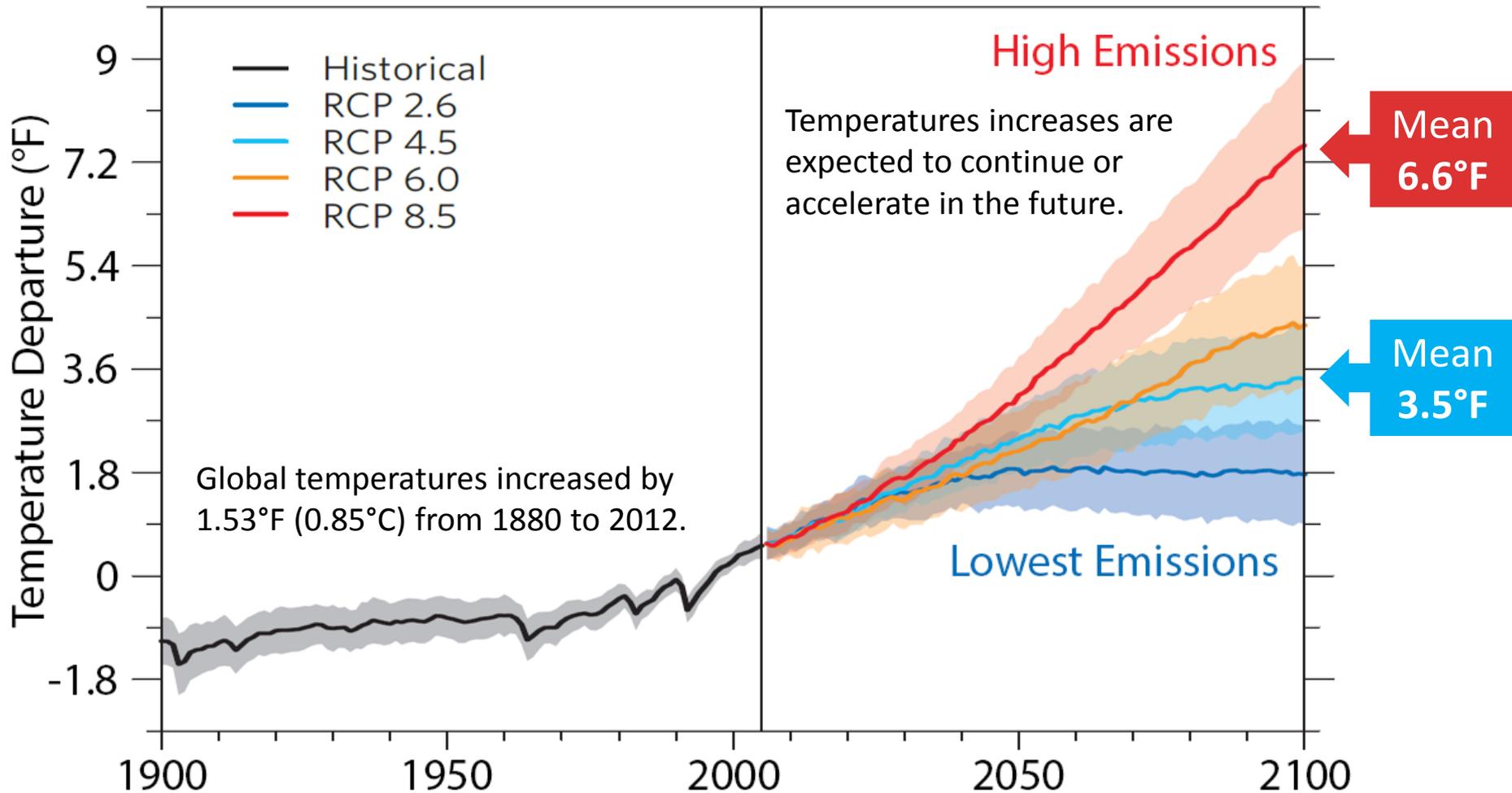
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GREAT LAKES INTEGRATED SCIENCES + ASSESSMENTS

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# Global Temperature



# Scale Matters: Global, Regional, Local

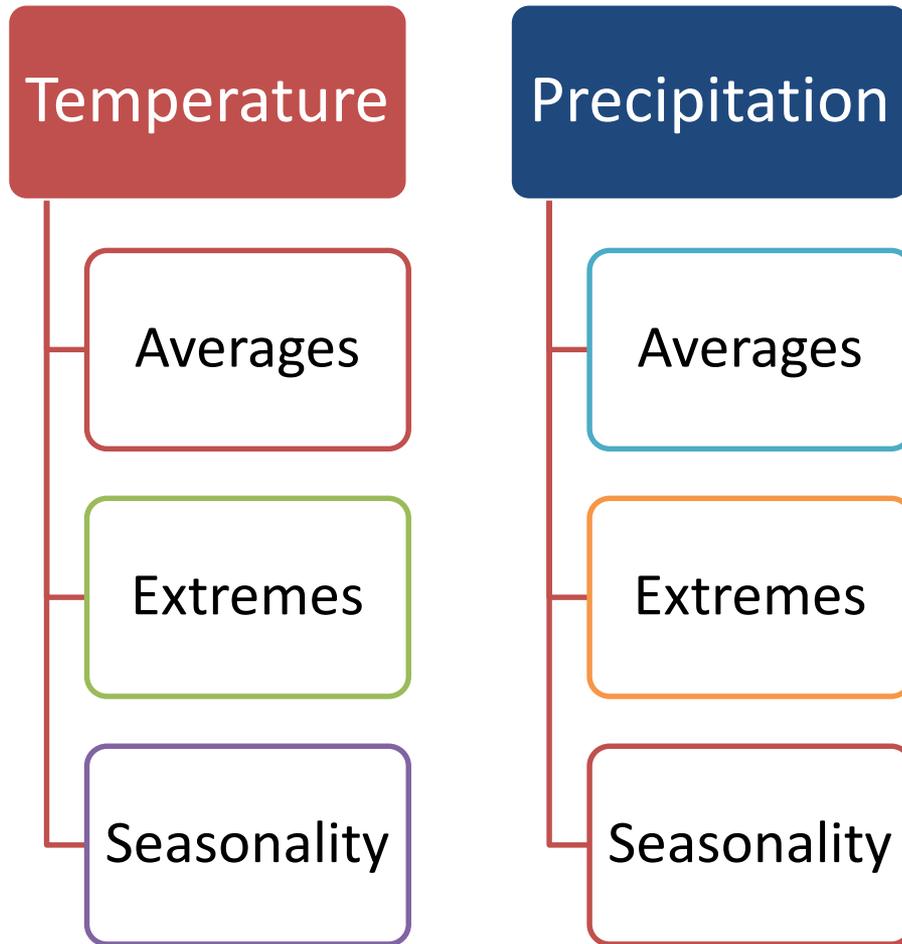


*Global trends are more certain than regional trends.*

*Natural variability plays a larger role at the regional scale.*

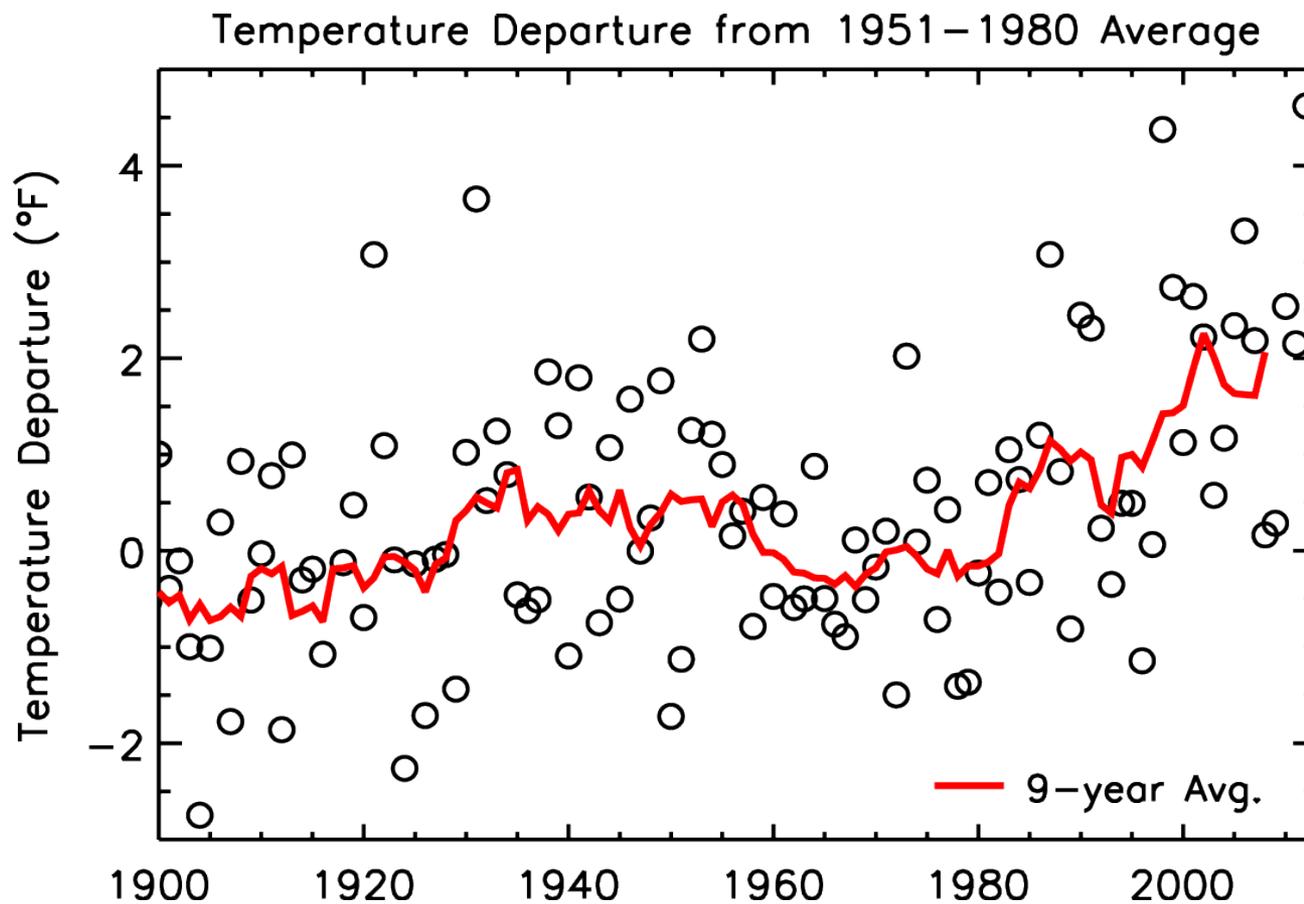
*Local changes in land use can alter the severity of climate change impacts.*

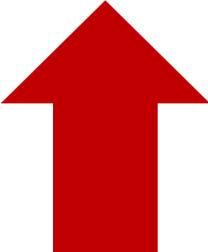
# What has Changed?



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

# Observed Regional Temperature



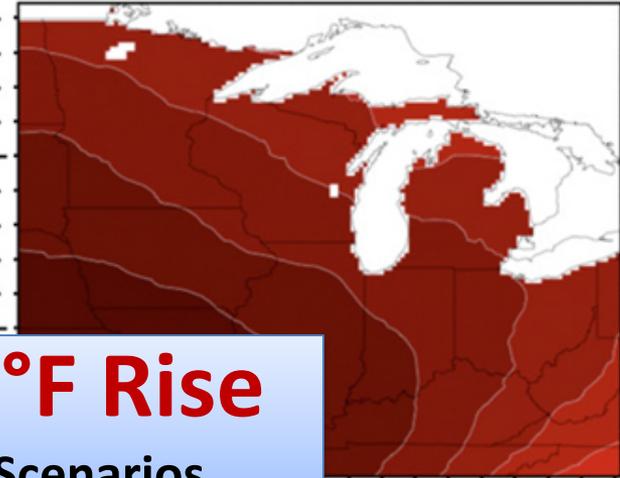
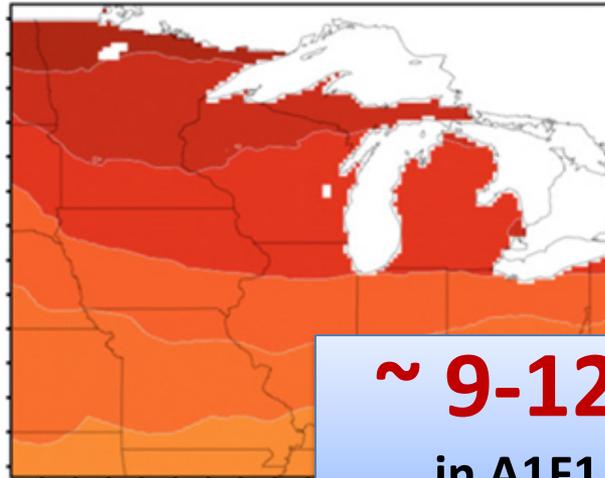
  
**2.0°F**  
**1.1°C**  
**1900-2012**

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

# Projected Midwest Temperature

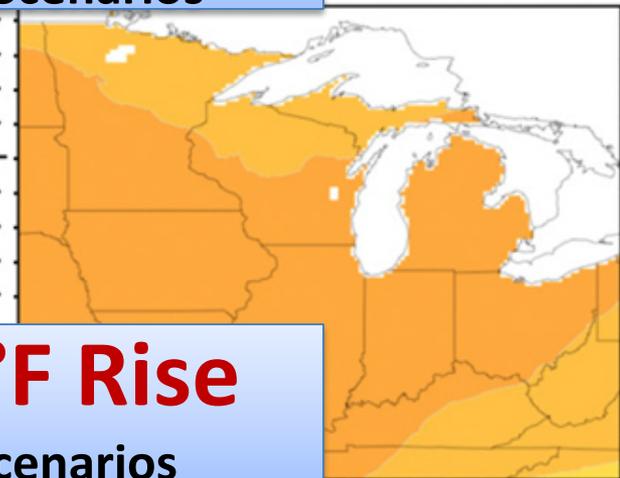
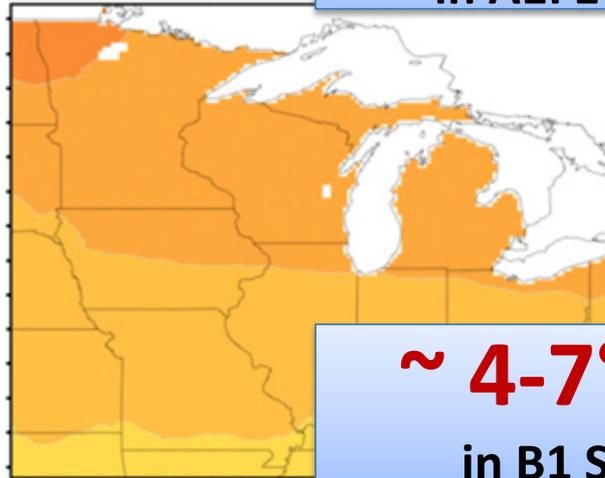
Winter, December - February      2070-2099      Summer, June - August

**Very High**  
Emissions  
Scenario

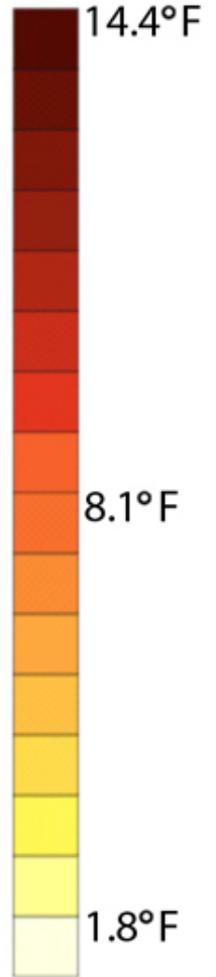


**~ 9-12°F Rise**  
in A1F1 Scenarios

**Low**  
Emissions  
Scenario



**~ 4-7°F Rise**  
in B1 Scenarios



Modified from Hayhoe et al, 2010

# Observed Heat Waves

The number of heat waves that pose risks to human health have increased in most major Midwestern cities.

Increasing overnight, minimum temperatures have increased at a faster rate, limiting relief during hot periods.

## Observed Change in Number of Harmful Heat Waves

**Chicago,  
IL**  
1948–2011  
(63 years)



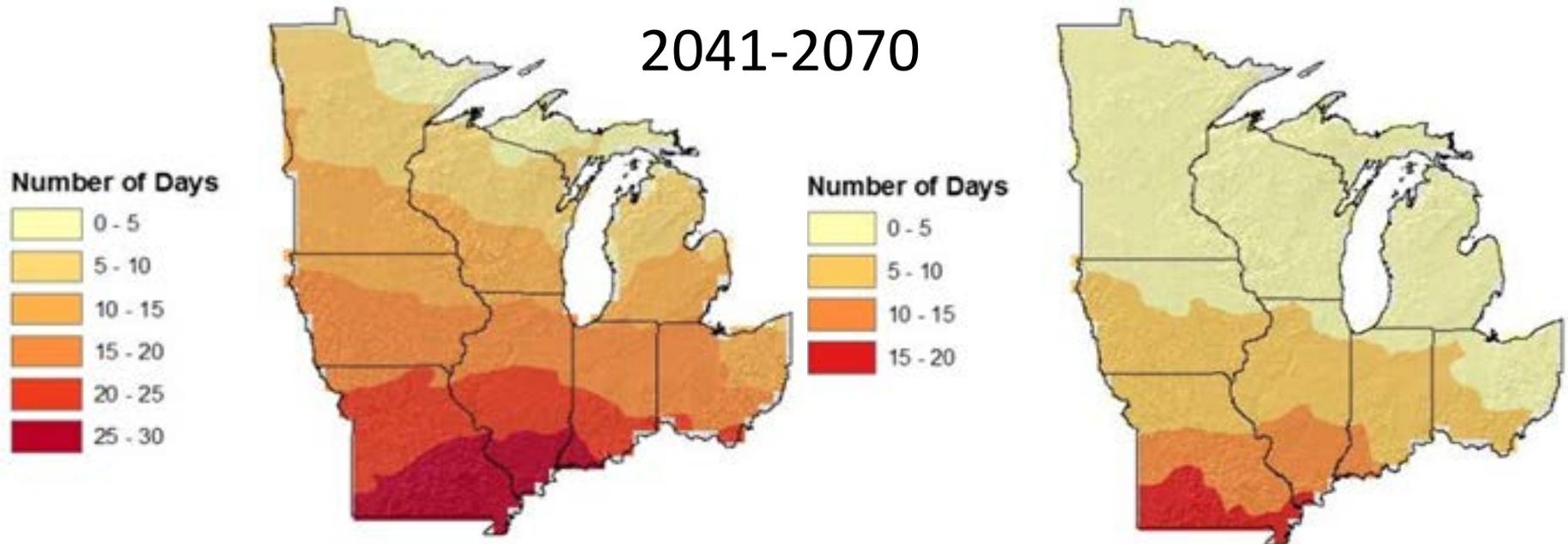
Increased  
1 per year

**Detroit,  
MI**  
1959–2011  
(52 years)



Increased  
2 per year

# More Hot Days Anticipated

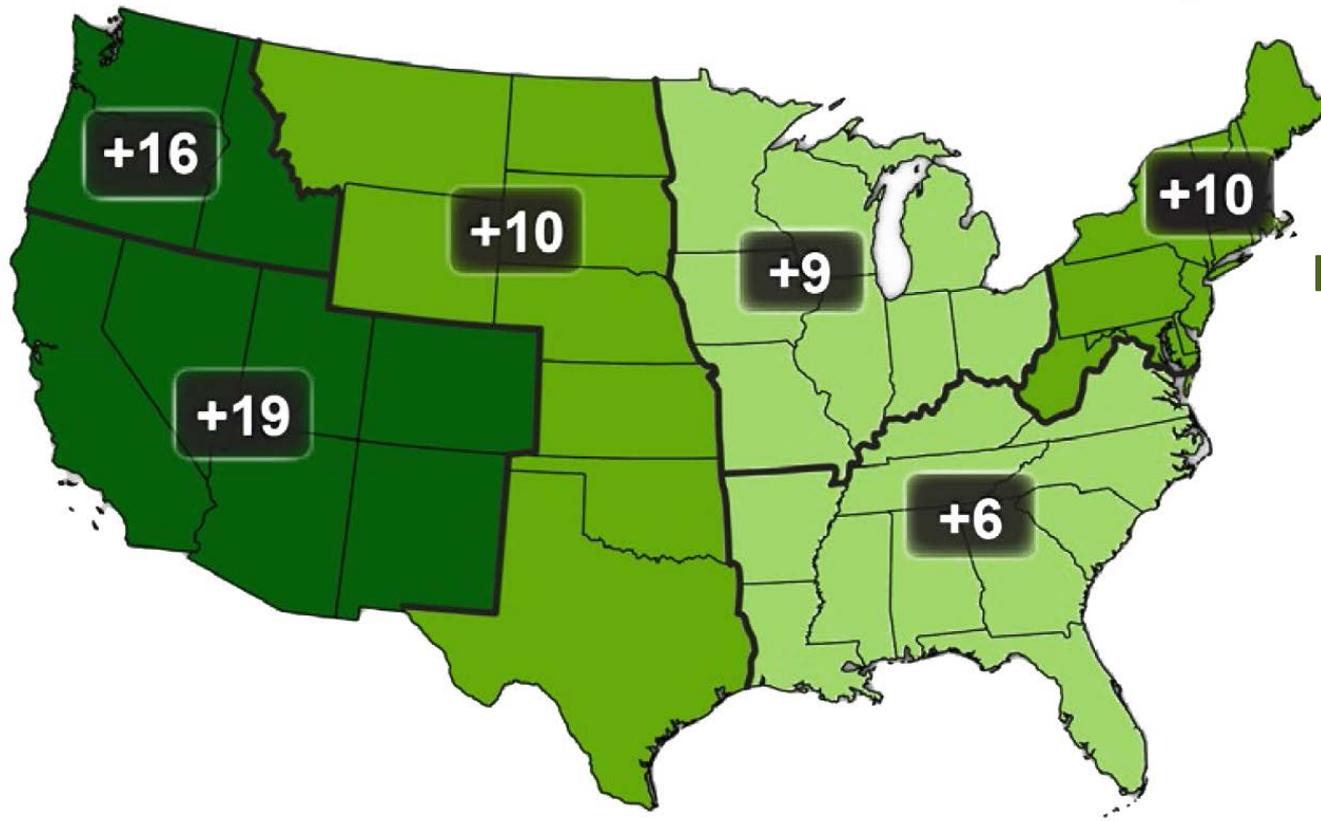


**Increase in Days  
> 95°F (35°C)**

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

# Longer Frost-free Season

Observed Increase in Frost-Free Season Length



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**

# The Great Lakes are Warming

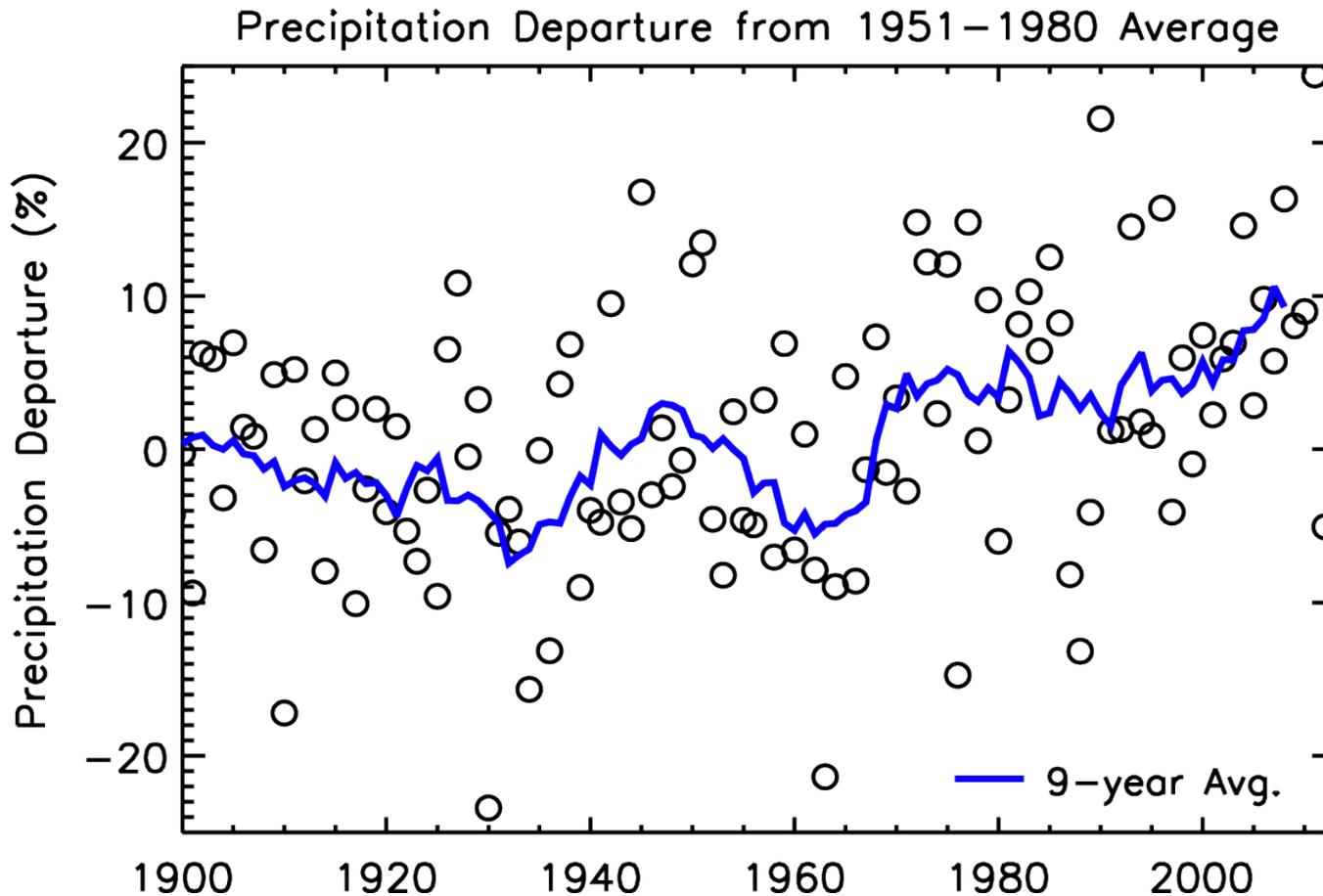
Average Great Lakes ice coverage  
*declined 71% percent* from 1973 to 2010  
Wang et al., 2012

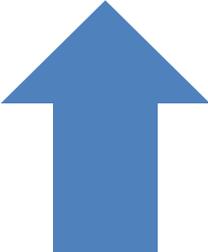
- Lake Superior is warming twice as fast as nearby air.
- Winter ice cover is decreasing.
- Lake Superior could have little to no open-lake ice cover during a typical winter within the next 30 years.



NASA

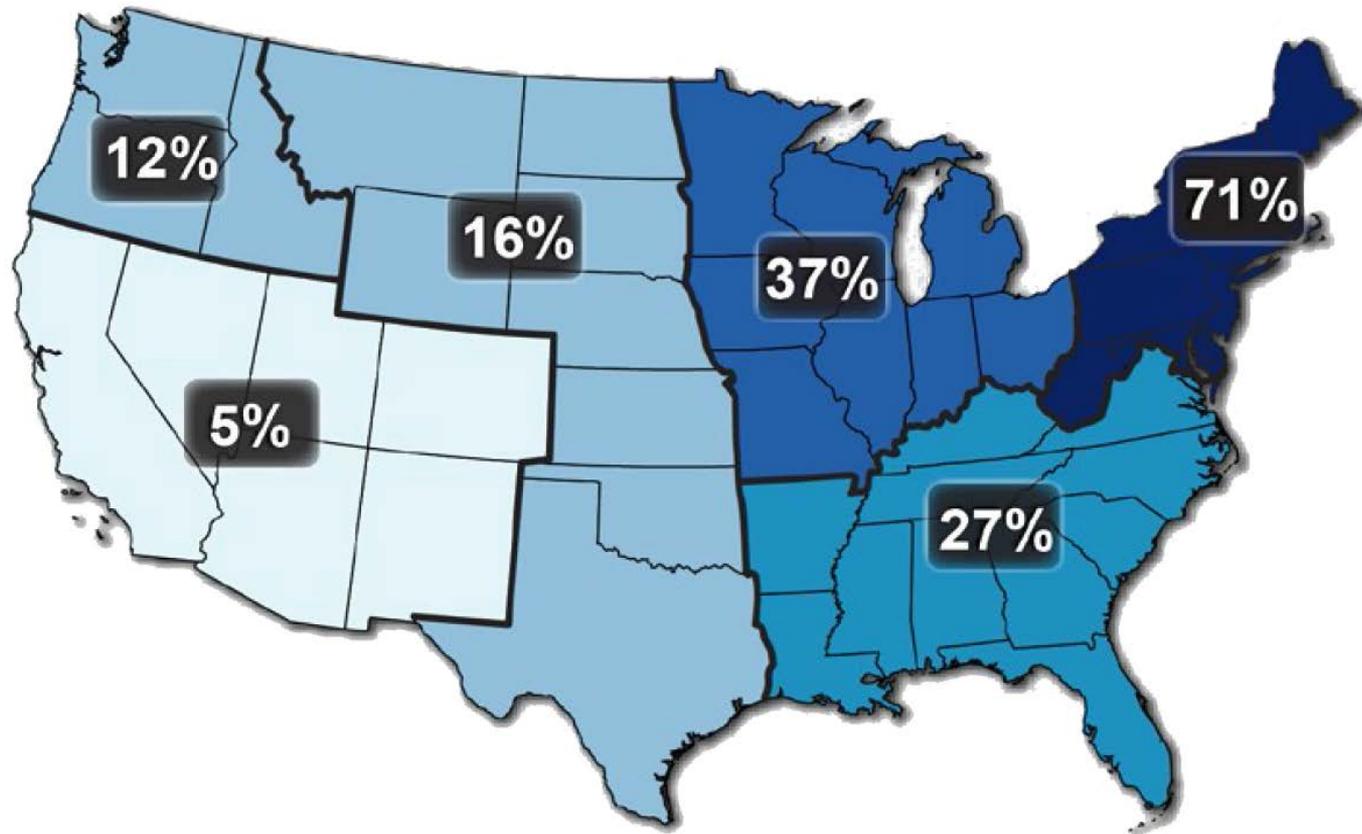
# Observed Regional Precipitation



  
**11%**  
**1900-2012**

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

# 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.**

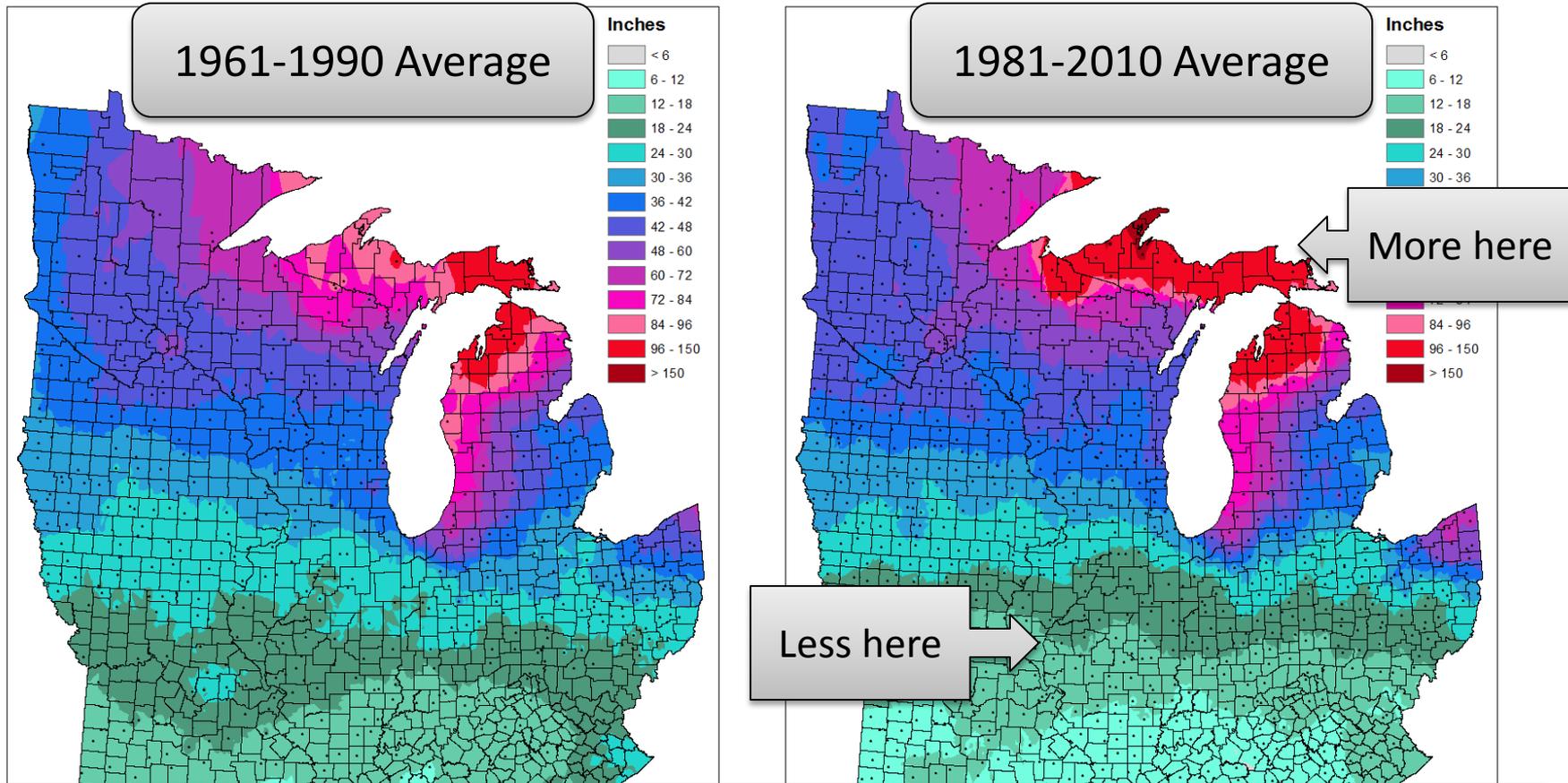
# Changing Precipitation Seasonality



- Shorter winters have led 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.

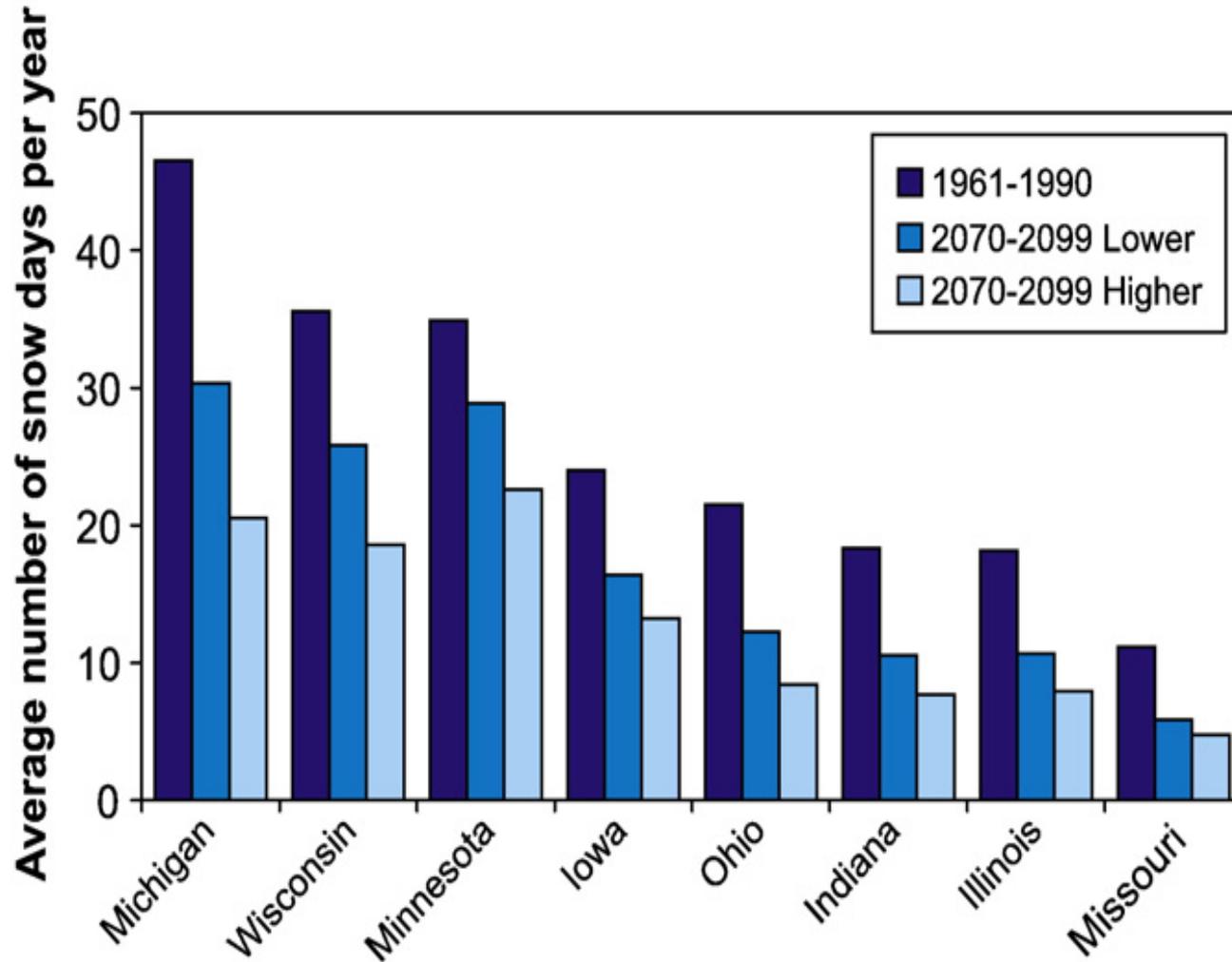


# Observed Snowfall



Snowfall has generally increased across the Northern Midwest, remained stable in the central latitudes, and has decreased in the southern areas.

# Projected Snowfall Days

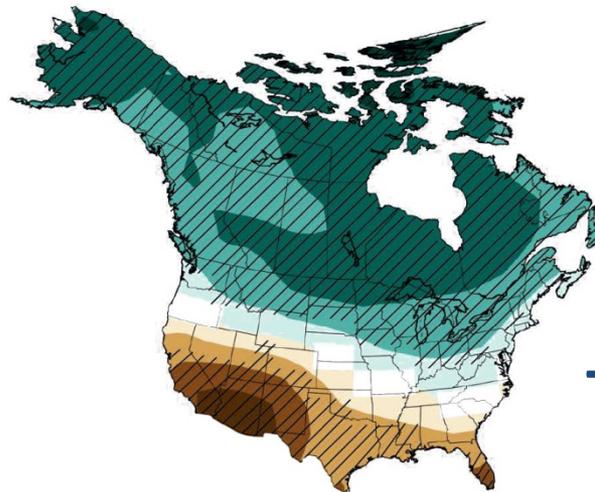
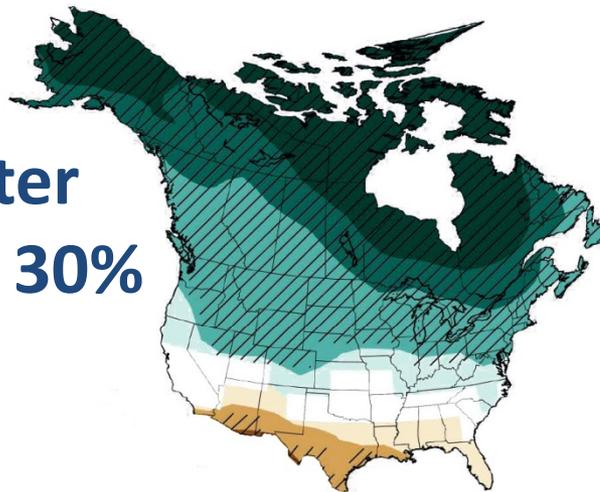


In high emissions scenarios, the number of snow events per year is expected to dramatically decline in Midwestern States by the end of the 21<sup>st</sup> century.

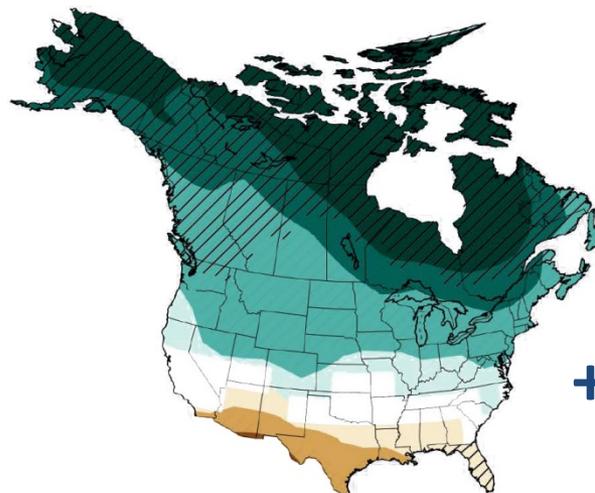
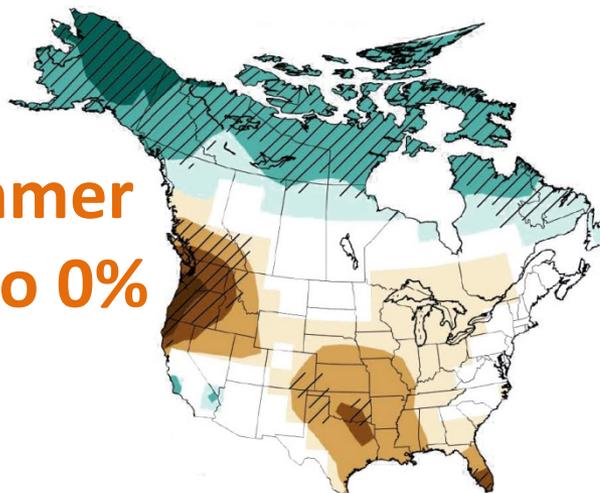
# Projected Precipitation

Projected Precipitation Change, A2 Emissions, 2070-2099

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



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



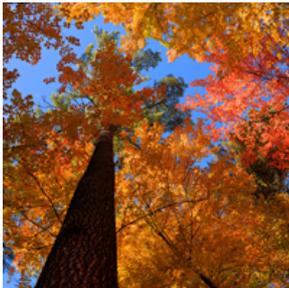
**Fall**  
**+0 to +30%**

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

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

# 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**

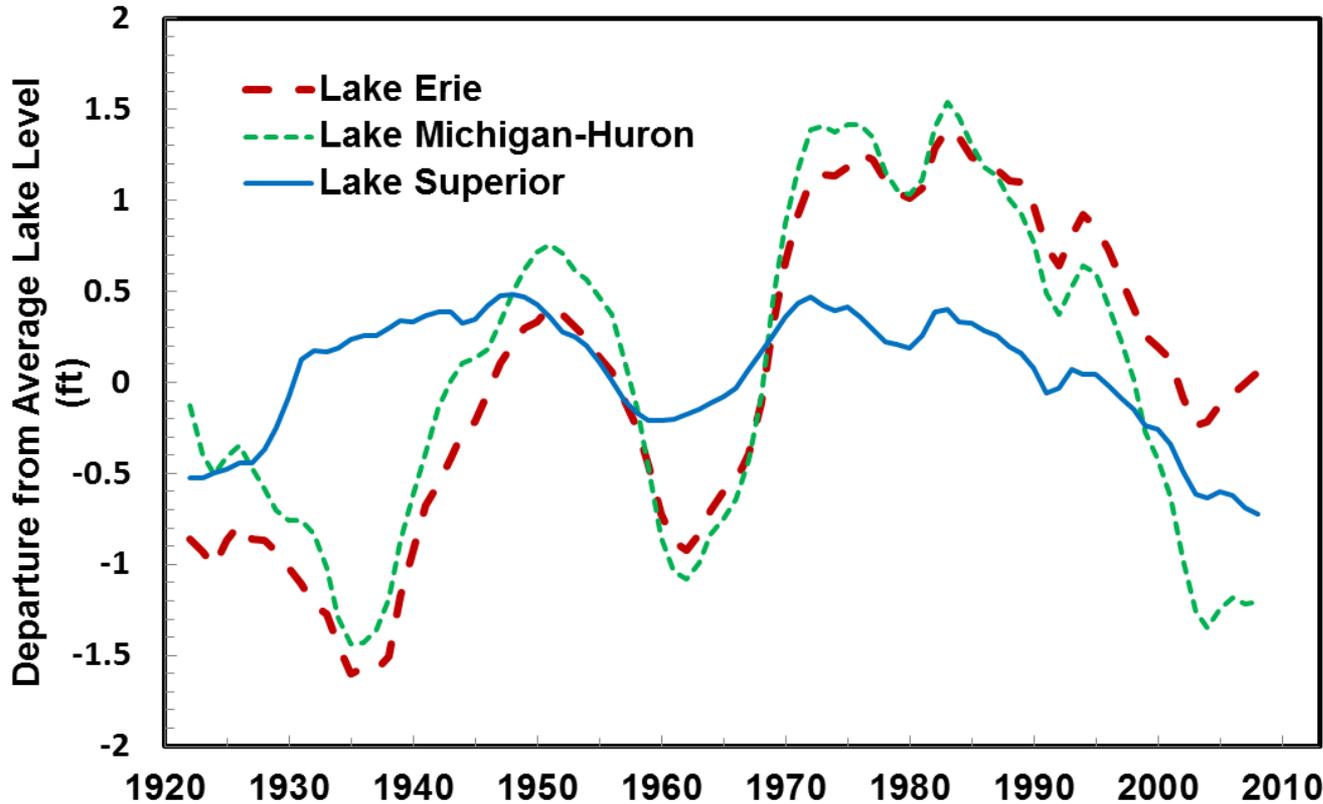


**Fish and Wildlife**



**Tourism and Recreation**

# 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.

# Learn More



[glisa.msu.edu](http://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?

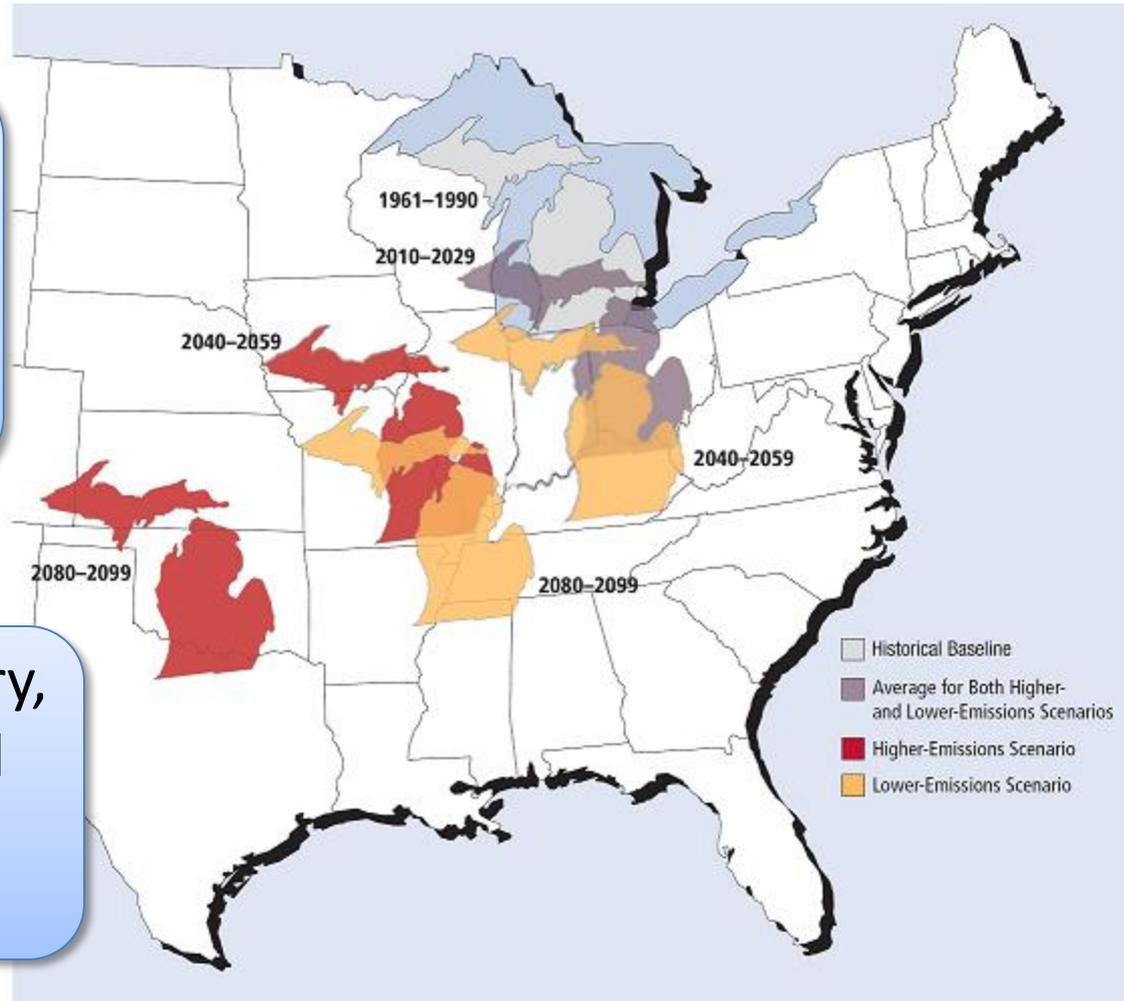
WINTER IS A PART OF OUR  
“SENSE OF PLACE”.  
WE ARE LOSING WINTER AS WE  
ONCE KNEW IT.

-JOHN MAGNUSON

# 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.