Climate Change in the Great Lakes Region
Global temperatures increased by 1.53°F (0.85°C) from 1880 to 2012. Temperatures increases are expected to continue or accelerate in the future.

From Knutti and Sedlacek, 2012
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

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

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

- **Very High Emissions Scenario**
  - Winter, December - February: ~ 9-12°F Rise in A1F1 Scenarios
  - Summer, June - August: ~ 4-7°F Rise in B1 Scenarios

- **Low Emissions Scenario**
  - Winter, December - February: ~ 9-12°F Rise in A1F1 Scenarios
  - Summer, June - August: ~ 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.
More Hot Days Anticipated

Increase in Days > 95°F (35°C)

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

Kunkel (2011)
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
The Great Lakes are Warming

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

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

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

Projected Precipitation Change, A2 Emissions, 2070-2099

- **Winter**: +10 to 30%
- **Spring**: +0 to +30%
- **Summer**: -20 to 0%
- **Fall**: +0 to +30%

**Annual**: +5 to 20%
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 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.
GLISA is a NOAA-funded partnership between the University of Michigan and Michigan State University.

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