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.
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.
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.
What has Changed?

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

Very High Emissions Scenario

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

~ 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.
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.

Wang et al., 2012

Austin and Colman, 2007
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.
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 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
Observed Snowfall

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

From MRCC

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1961-1990 Average

1981-2010 Average

More here

Less here

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.
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
Impacts of Declining Great Lakes Ice Cover

- **Fishing Industry**: Ice cover protects whitefish spawning areas. Great Lakes commercial fishing is a $4 billion industry.
- **Coastal Zone**: In nearshore areas, ice provides a 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.

Wang et al., 2012
Flooding and Stormwater

With increased extreme precipitation events, intense, flashy runoff amplify flooding risks.
Conspiring Changes: Water Quality

- Warmer Lake Temperatures
- Stronger Storms
- Changed Lake Dynamics
- Greater Nutrient Loading
- More Runoff
- Algal Blooms, Fish Kills
Algal Blooms and Fish Kills

Climate Change will increase the risk of many existing water quality and environmental issues.
Migrating Plant Hardiness Zones

Average extreme minimum temperatures, which test the hardiness of plants to cold, have migrated north, allowing for different plant types to survive in those areas.
Traditional northern forests of maple, beech, and birch may slowly lose their advantage over species that thrive under warmer conditions to the south.
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.
Climate Change 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.
Agriculture Vulnerabilities Example: Spring 2012 and Cherry Crops

- The early warming was an 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 dollar loss** from tart cherries alone
How will we adapt?

Winter is a part of our “Sense of Place”. We are losing Winter as we once knew it.

-John Magnuson
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.

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