Resilient Waters, Resilient Cities
Climate Change in the Great Lakes

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Great Lakes Integrated Sciences + Assessments
1. Climate Change in the Great Lakes
2. Impacts on Water and Cities
3. Acting Through Uncertainty
Global Carbon Cycle

The natural cycle adds and removes CO$_2$ to keep a balance. Humans add extra CO2 without removing any.
Historic Carbon Dioxide Concentration

A natural change of 100ppm normally occurs over 5,000 to 20,000 years.

The recent increase of 100ppm has taken 120 years.

Fact Source: EPA. Image Source, Scripps Institute of Oceanography
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.
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

Projected Change in Number of Days Over 90°F
Period: 2041-2070 | Higher Emissions: A2

Ann Arbor, MI could experience 25-35 more days on average over 90 degrees vs. 1971-2000

5-10 more days over 95 degrees.
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.
Observation Extreme Precipitation

Following methodology from Groisman et al, 2005, updated.

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
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%
The Great Lakes are Warming

- 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.

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

Wang et al., 2012

NASA

Austin and Colman, 2007
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.
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
Flooding and Stormwater

With increased extreme precipitation events, intense, flashy runoff amplify flooding risks.
Rising temperatures, degrading infrastructure, and more severe precipitation may conspire to increase risks to water quality.

The impacts could be felt in many sectors, including public health, recreation and tourism, and environmental management.
Coping with Uncertainty

Adaptation Space

Temperature Departure (°F)

1900 1950 2000 2050 2100

Historical
RCP 2.6
RCP 4.5
RCP 6.0
RCP 8.5

High Emissions
Lowest Emissions

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

What Has Changed

What Will Change

What are the impacts
Recognizing Uncertainty
Moving to Action

- Gather the facts
- Find a community
- Develop adaptive management solution
- Act!
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