Module 1A: Introduction to Climate Change in the Great Lakes

Overview

1. Climate change across scales
2. Observations & projections in the Great Lakes
3. Impacts on Great Lakes cities

Image source: NASA's Marshall Space Flight, Flickr, June 14, 2012

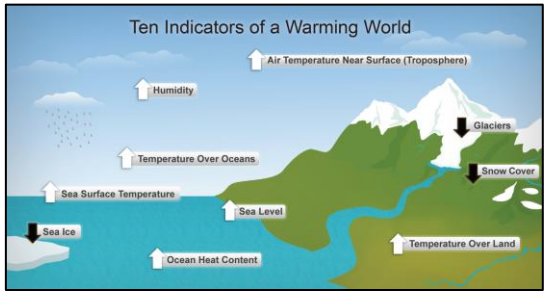
Climate change across scales

CLIMATE CHANGE: GLOBAL PHENOMENON, LOCAL EFFECTS

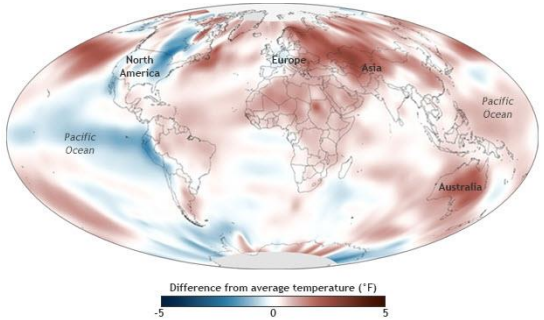
Climate change across scales

Global climate change

Observed changes: Indicators measured globally over many decades show the Earth's climate is warming.



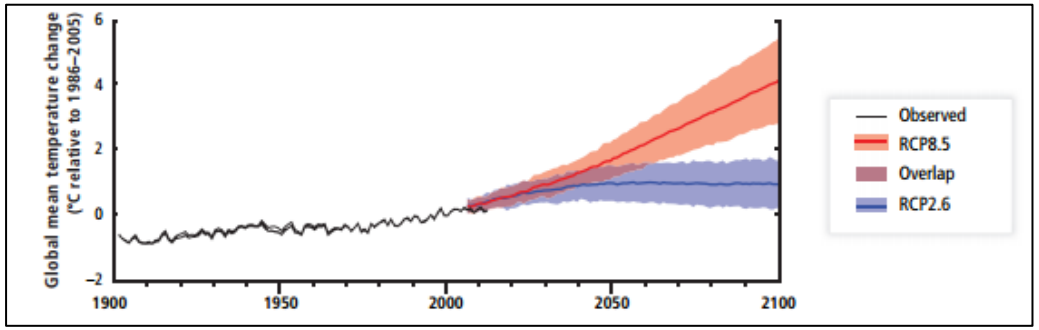
[Ten Signs of a Warming World]
(NOAA)



[2013 State of the Climate Report]
(NOAA & the AMS)

[IPCC AR5, 2013]**:** *High confidence* that human influence on the climate has warmed the ocean, melted snow and ice, raised global mean sea level and changed some climate extremes in the second half of the 20th century.

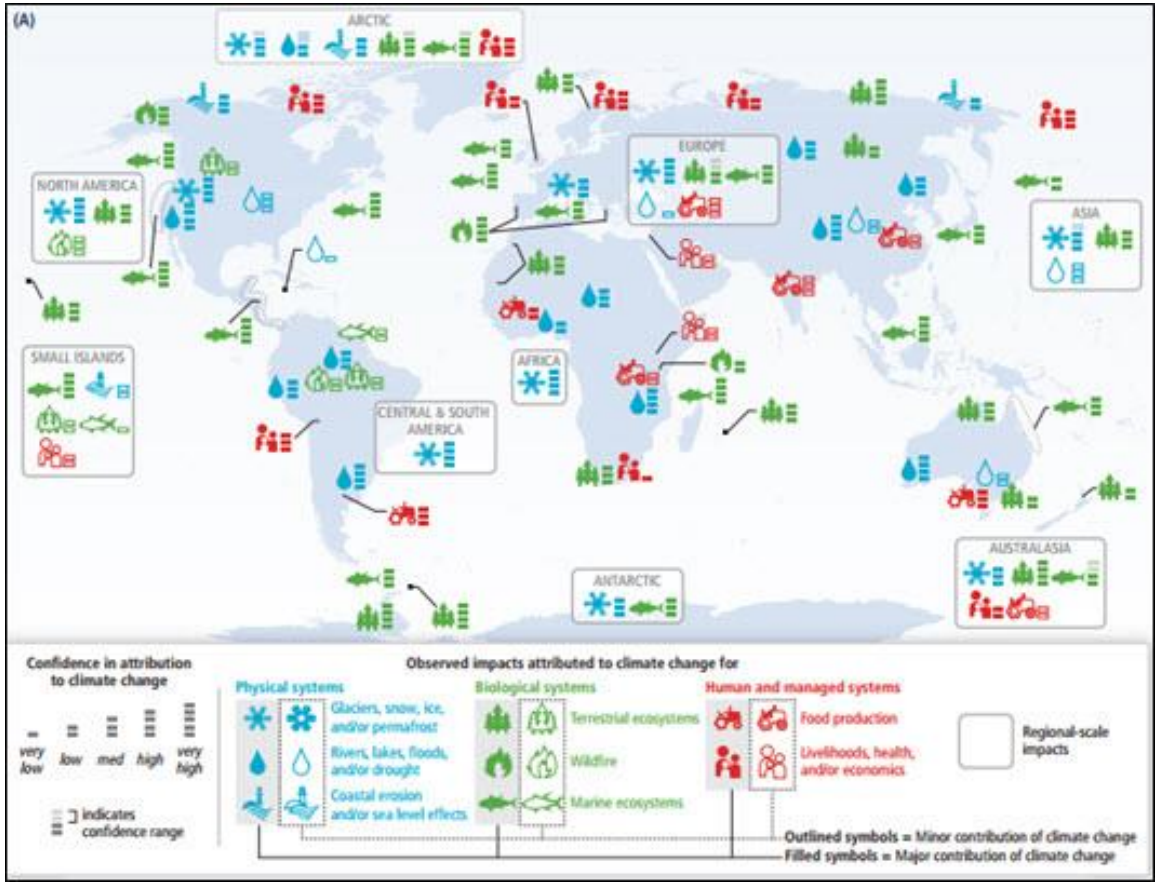
Future projections: Continued or increasing warming in all emissions scenarios



[IPCC AR5]

Climate change across scales

Global climate change: Widespread impacts

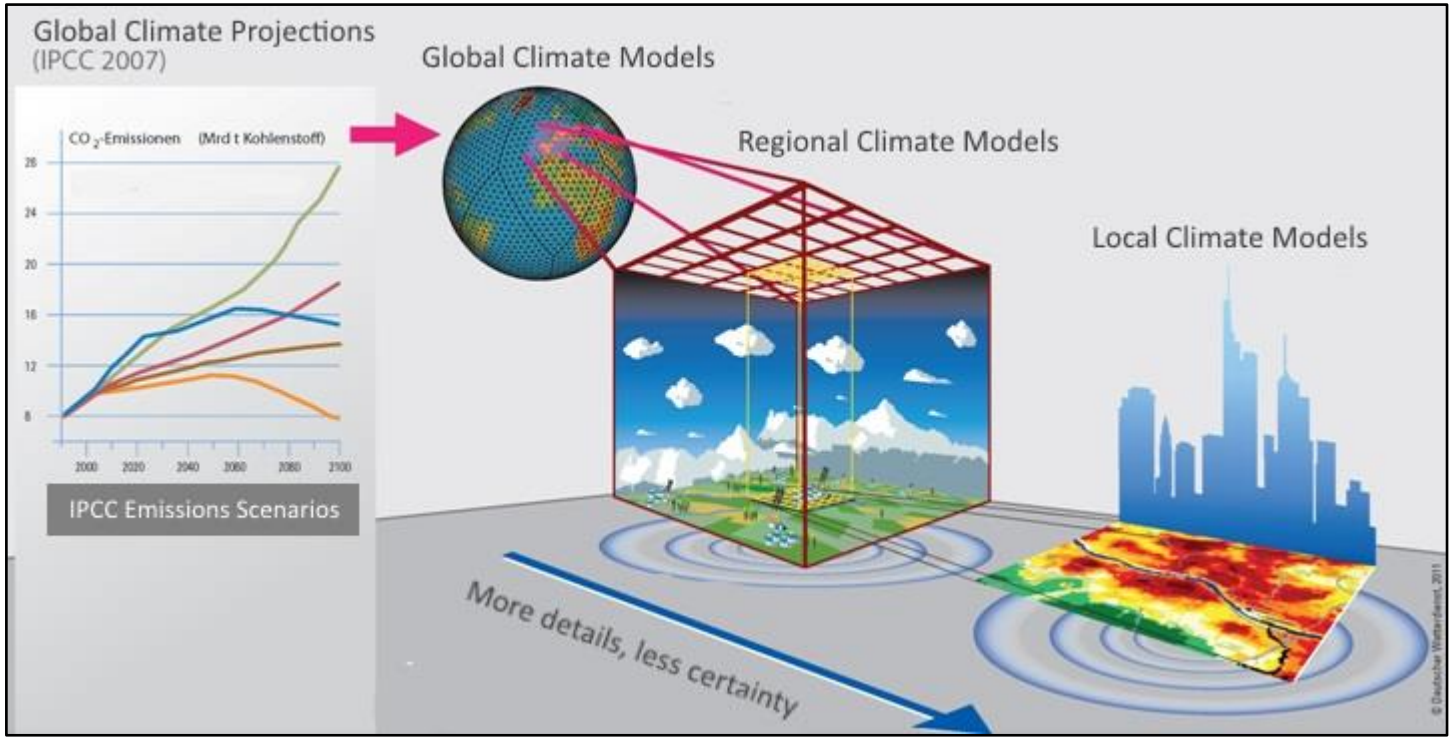


Now that there is strong international consensus about the significance of global climate change, scientists and decision makers are focusing on understanding regional and local impacts in order to respond effectively.

Image source: [IPCC 2013, AR5, Summary for Policymakers]

Climate change across scales

Global averages mask regional differences



Climate change is global in its nature; however, its precise impacts will vary on a regional level.

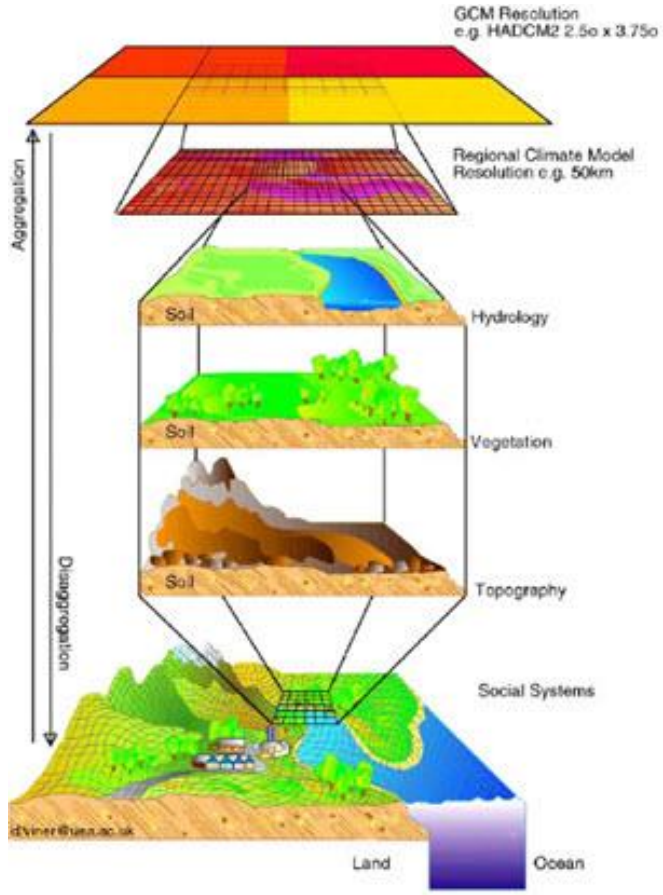
Natural variability plays a larger role at the regional scale due to changes in land use (e.g. urbanization) and geographic features (e.g. mountains and lakes).

Thus, local practitioners turn to downscaled global climate information.

Image source: Deutscher Wetterdienst, Klimaprojekten fuer die Stadtplannung (German Weather Service, Climate Project for Urban Planning)

Climate change across scales

Historical trends and future projections



When assessing climate change in your region, consider both historical trends *and* future projections:

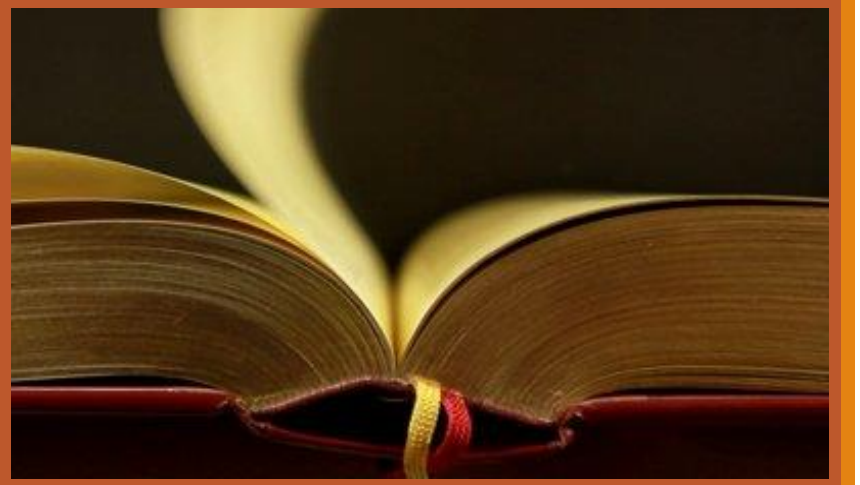
Historical trends focus on observed climate data that was recorded by climate stations in the past century. These trends provide greater certainty to estimate near-term weather, but aren't good at predicting extreme events.

Climate projections provide an idea of what to expect over the next century, but lose certainty as they are downscaled to the regional level.

Climate preparedness and resilience does not necessarily require climate data, but this data helps build the case for adaptation for city council and residents, and allows us to better prepare for extremes.

Image source: ConsulClimate, Downscaling GCM Outputs, http://consulclima.co.uk

Additional Resources:



Global and National Climate Change

- **NOAA & BAMS State of the Climate**
  Peer-reviewed assessment of the world's climate released annually by NOAA and BAMS. 2013 report includes information on extreme events, surface temperature, global sea level, ocean heat content and more.

- **IPCC Assessment Reports**
  Peer-reviewed synthesis of the latest climate science, as well as number of special reports on particular topics, released every 6-7 years. Reports are prepared by teams of hundreds of international researchers.

- **US National Climate Assessment**
  US government interagency report focusing on observed changes, projected impacts to the US, and the state of adaptation and mitigation. It's released every 4 years

- **An Overview of Canada's Changing Climate**
  Chapter 2 of 2014 "Canada in a Changing Climate" report. Led by Natural Resources Canada, the development of the report involved over 90 authors and 115 expert reviewers.

Understanding Climate Models

- **Oregon SeaGrant Video (4:43 mins)**

- **World Meteorological Organization: Climate Models**

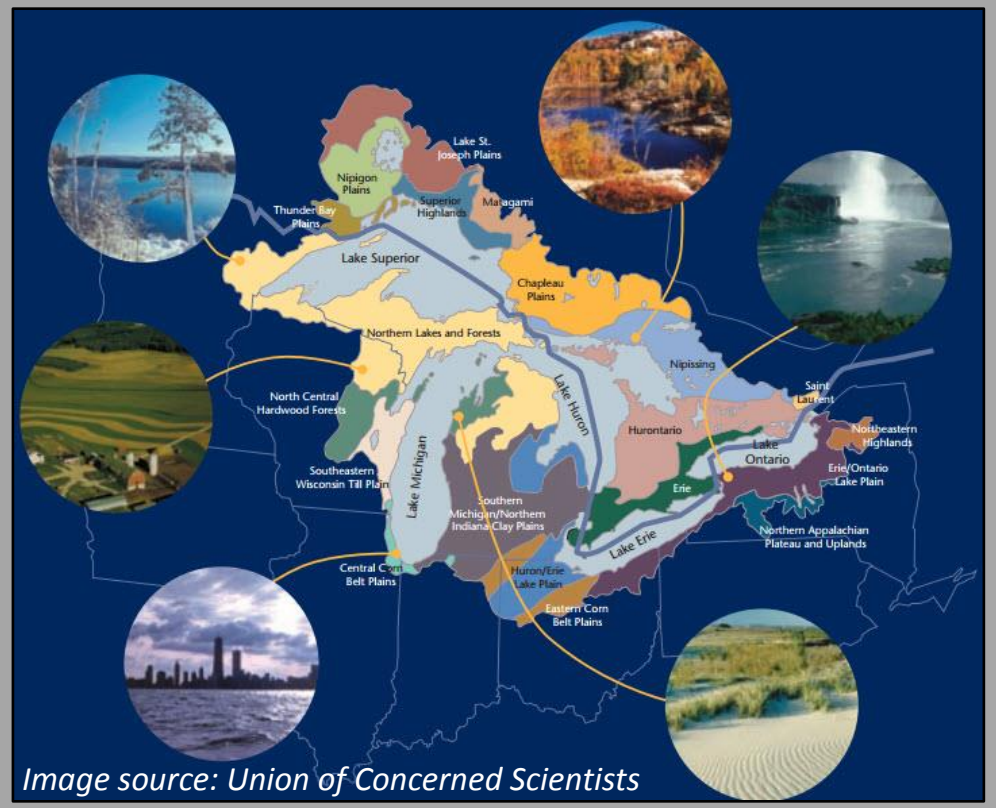


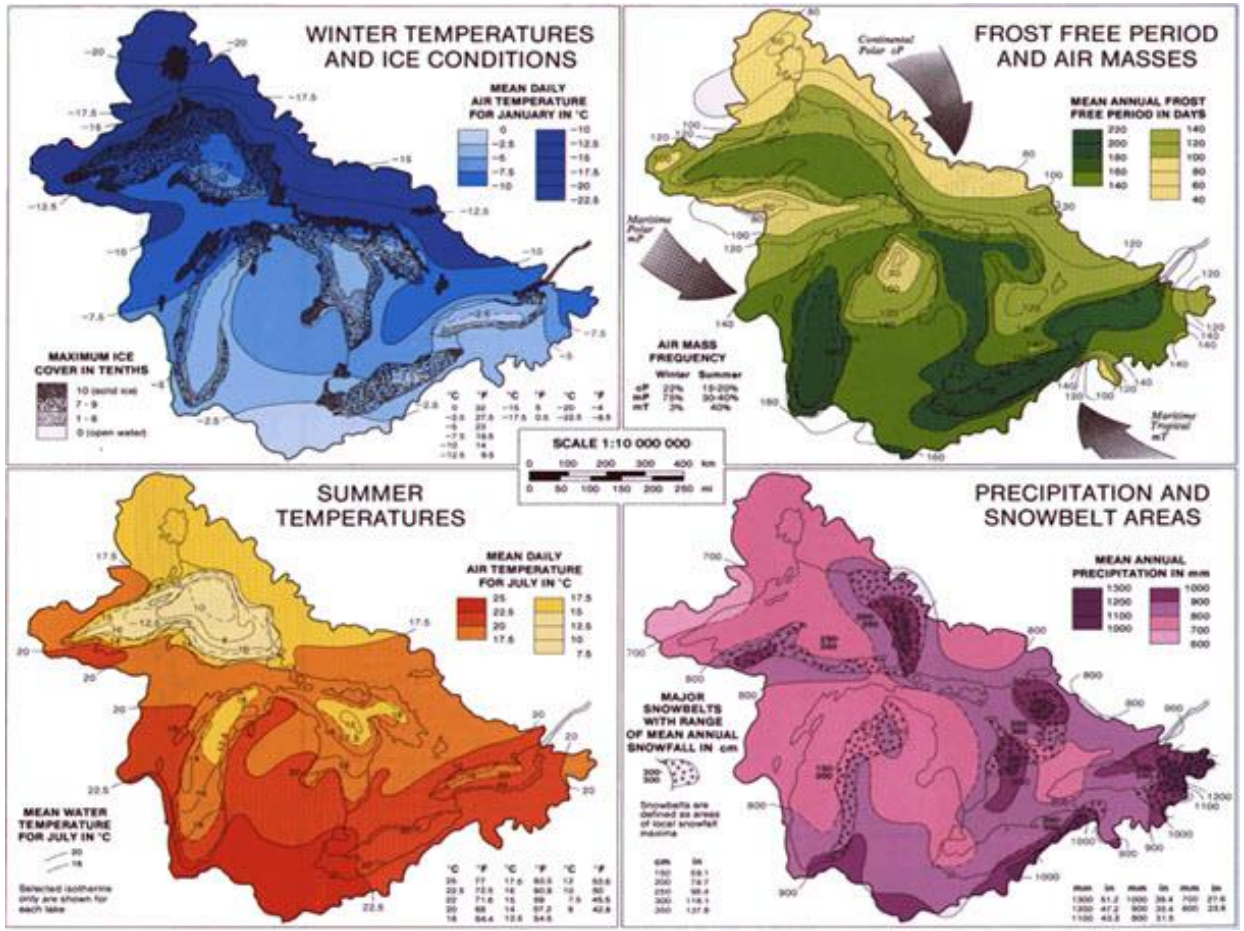
Image source: Union of Concerned Scientists

Climate Change in the Great Lakes

HISTORICAL OBSERVATIONS & FUTURE PROJECTIONS

Climate change in the Great Lakes

Regional variation due to the lake effect



The Great Lakes significantly influence the region's micro-climates by:

- ...moderating the temperature of surrounding land.
- ...increasing the moisture content of the air throughout the year.

So, cities on southern shorelines may deal with different impacts than those along a northern shore! It's critical to take lake effect, as well as land changes due to urbanization and agriculture into account.

Image source: Environment Canada and U.S. Environmental Protection Agency. 1995. Great Lakes Atlas.

Observations and projections in the Great Lakes

Observed changes since 1900

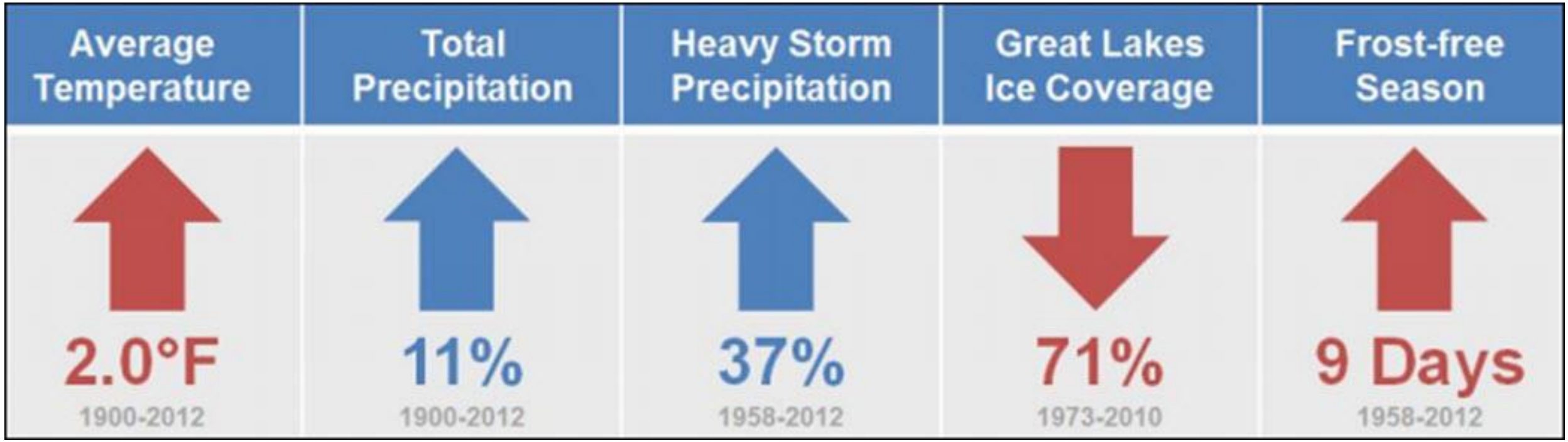


Image source: GLISA, Climate Change in the Great Lakes Region, 6/18/2014, http://glisa.msu.edu

Observations and projections in the Great Lakes

Projected changes through 2099

The climate future generations experience in the Great Lakes will be fundamentally different than the climate today.

What is changing?

Scientists often discuss changes in terms of averages, but our environments are managed in terms of timing and extremes. Thus, we take into account precipitation and temperature:

- Averages
- Extremes
- Seasonality

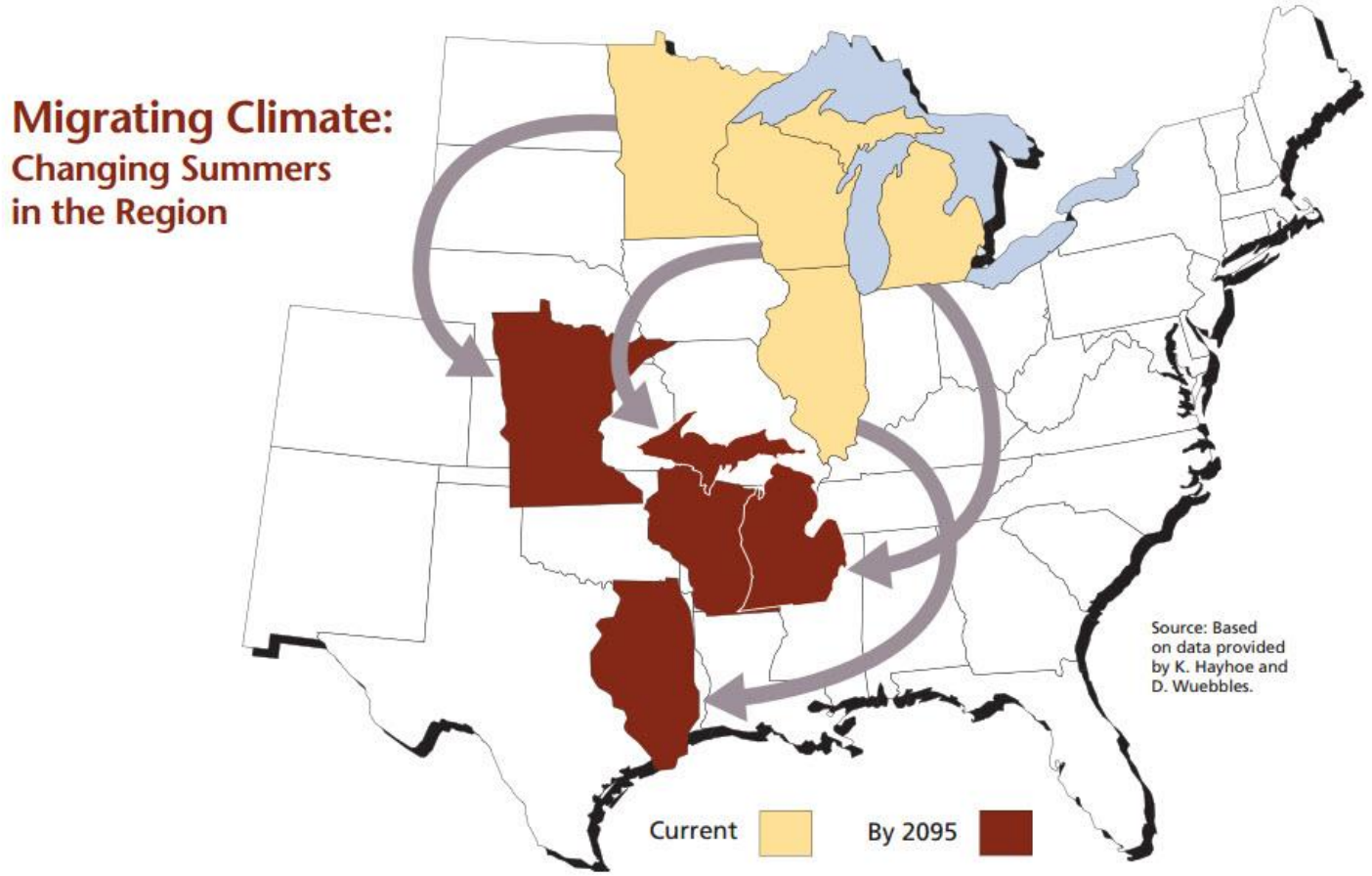
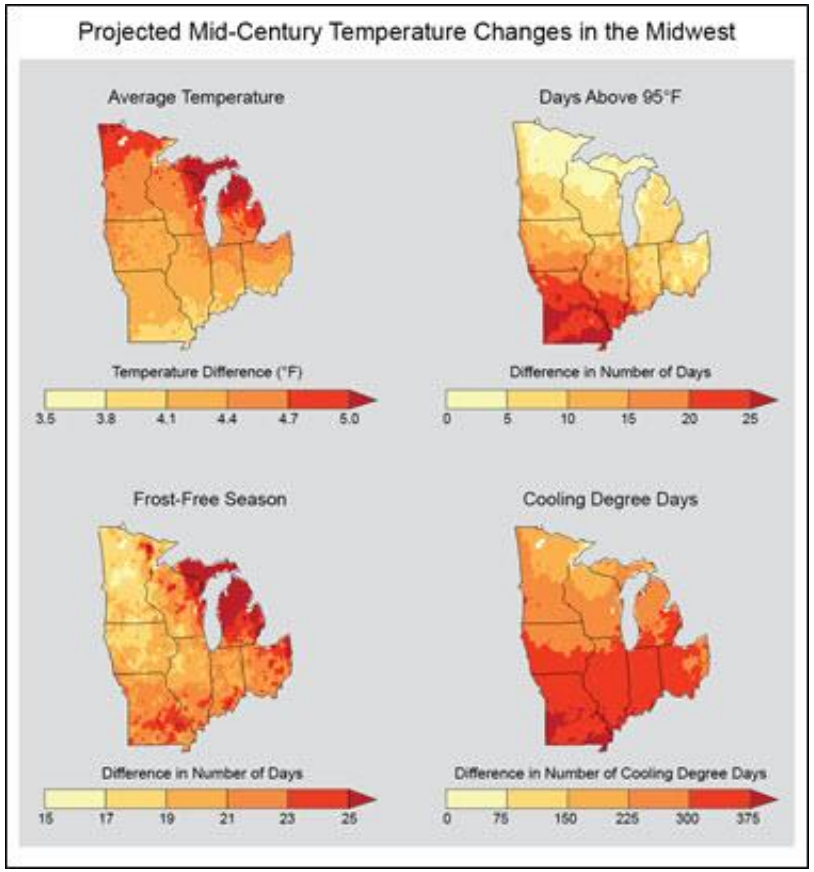


Image source: Union of Concerned Scientists, Confronting Climate Change in the Great Lakes, 2005

Observations and projections in the Great Lakes

Temperature: More hot days each year



Higher annual average temperatures:
Historical trends show increasing rise in temperatures. Rise projected to continue.

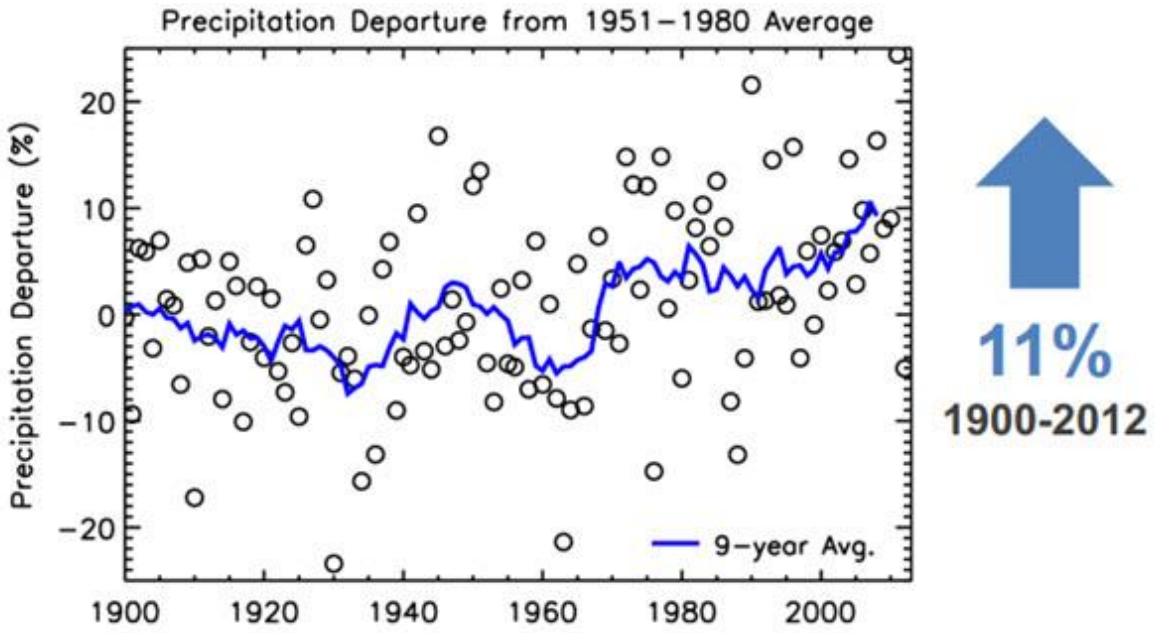
Increased extremes:
Increase in frequency of 95°F+ days

Change in seasonality:
Frost-free season has increased by 9 days compared to 1901-1960.

Image source: Climate Change Impacts in the United States: The Third National Climate Assessment Report

Observations and projections in the Great Lakes

Precipitation: More severe weather



11%
1900-2012

Increased annual precipitation:
Increase is expected to continue, though regional projections of future precipitation vary.

Increased extremes:
Precipitation via heaviest 1% of storms increased by 37% in the US Midwest from 1958 through 2012.

Climate change increases floods *and* droughts in the region.

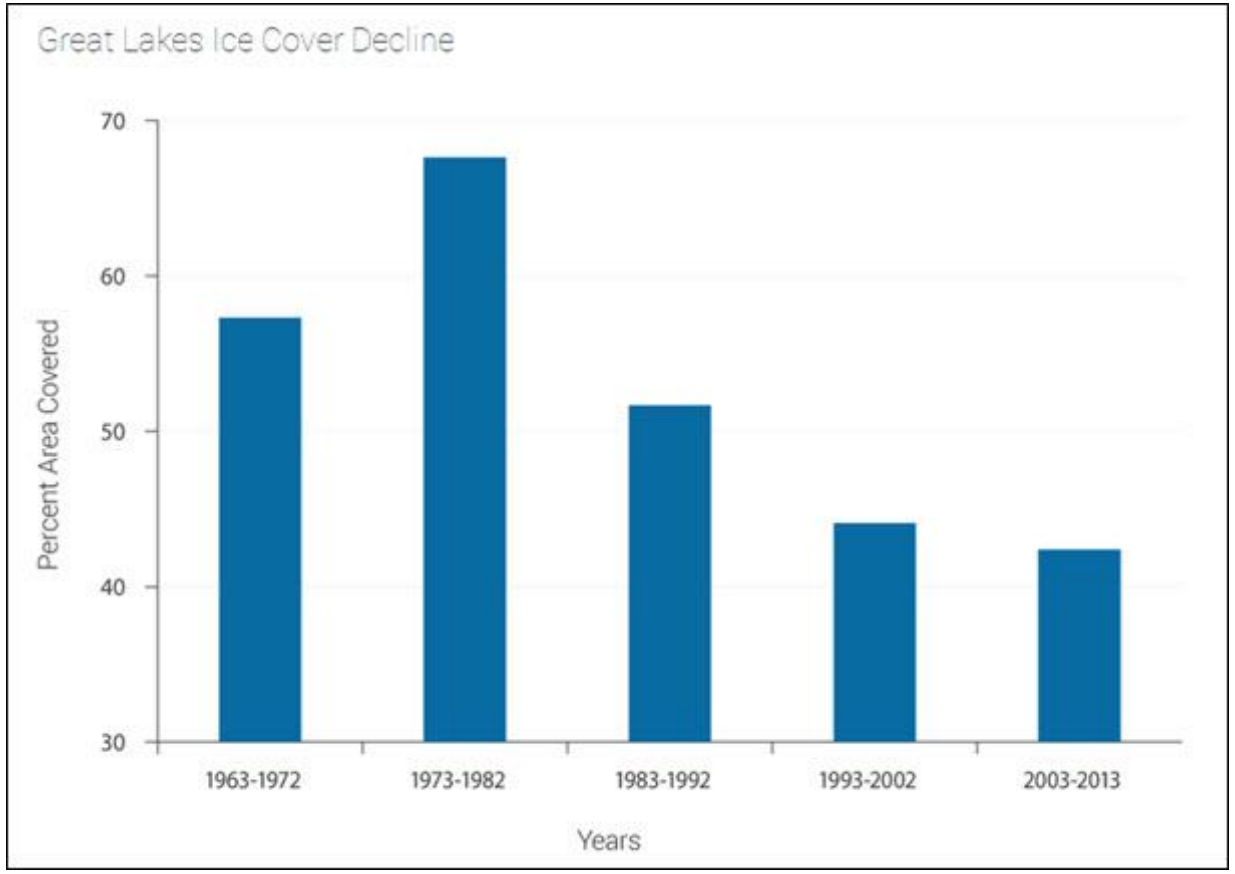
Change in seasonality:
More precipitation is falling as rain instead of snow.

Snow melt:
Rapid winter snow melts, combined with precipitation events, can lead to extensive flooding.

Image source: GLISA, Weighted averages of nClimDiv divisional data from 8 U.S. Great Lakes States.

Observations and projections in the Great Lakes

Lake levels and ice cover: downward trend



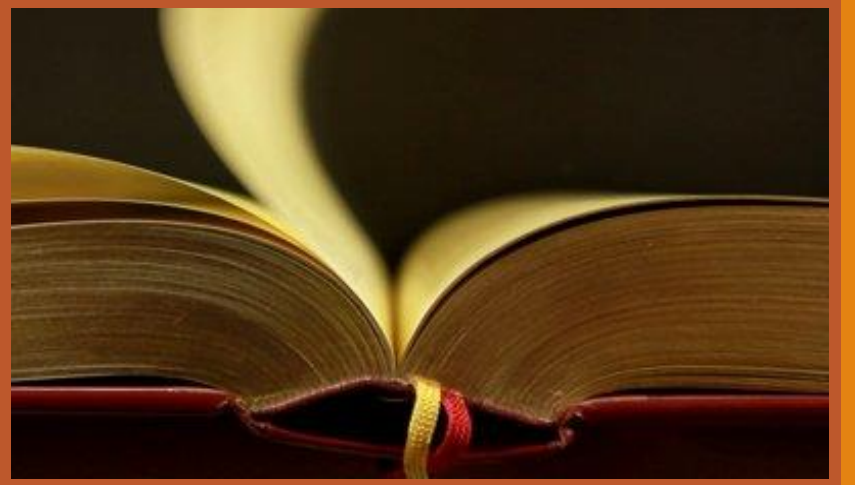
Lake levels: Still some uncertainty, but likely overall trend is downward.

Year to year fluctuations due to other environmental factors (e.g. solar radiation, precipitation, wind speed, etc).

Ice cover: Rising temperatures will continue to lead to a reduction in seasonal ice cover.

Image source: Kenneth Kunkel, Cooperative Institute for Climate and Satellites - NC

Additional Resources:



Great Lakes Climate Information

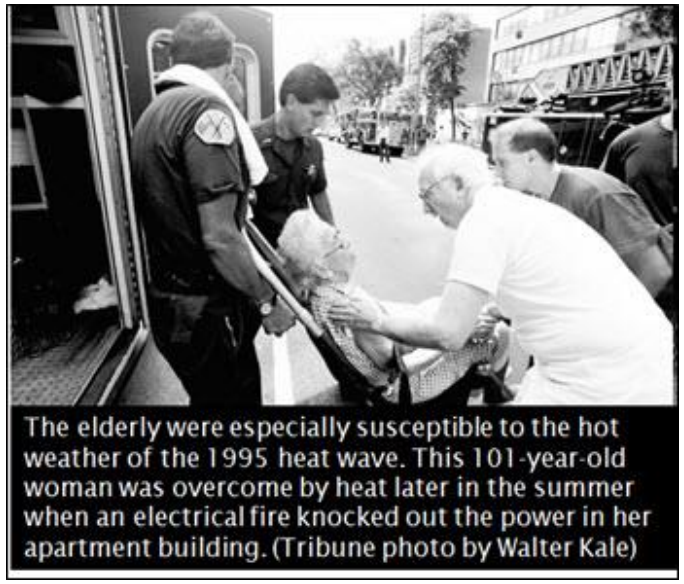
- Climate.gov
- Latest Regional Climate Impacts and Outlooks (NOAA)
- Cities Impacts & Adaptation Tool (GLISA Tool)
  provides usable data such as demographics, socioeconomic data, and both current and projected climate trends.
- Summary Climate Information (GLISA Resources)
  GLISA provides accessible information about the climate change issues we face in the Great Lakes region. These materials provide valuable background information for those considering Great Lakes climate.
- Great Lakes Station Climatologies
  Find summaries of the observed historical climate for select sites across the Great Lakes region. Each summary includes an overview of temperature and precipitation to help guide local-level climate adaptation decisions.
- Canadian Climate Change Scenarios
  These maps provide a visual image of how the climate will change in any particular scenario, compared to the baseline climate period.
- Great Lakes Water Level Dashboard

Impacts on Great Lakes Cities

THE CASE FOR ADAPTATION ACROSS MUNICIPAL SECTORS

Impacts on Great Lakes cities

Health and vulnerable populations



The elderly were especially susceptible to the hot weather of the 1995 heat wave. This 101-year-old woman was overcome by heat later in the summer when an electrical fire knocked out the power in her apartment building. (Tribune photo by Walter Kale)

Heat waves can be deadly:

- Chicago 1995: 550+ deaths
- Toronto 2005: 6 known deaths
- Ontario 2005: 17,000 hospital admissions and 60,000 emergency room visits due to air pollution

Heat risks:

- Heat related illnesses and deaths especially affect elderly, homeless, low-income, children
- Increased smog will worsen asthma
- Increase in food-borne illnesses
- Increase in ragweed pollen season
- Tick and mosquito habitat will increase

Precipitation risks:

- Increased waterborne diseases
- Injuries and deaths from flooding & winter storms
- Increases in basement mold from flooding events

Image source: Chicago Tribune, July 13, 1995

Impacts on Great Lakes cities

Government finance

Climate change related costs for municipalities:

- Repairing municipal infrastructure, facilities & parks
- Premature infrastructure replacement and increased maintenance
- Weather emergency expenditures
- Subsidies for uninsured residents & businesses
- Increased insurance costs
- Loss of taxes and incomes due to business disruption
- Lawsuits

Lower budgeting predictability:

- Extreme events --> unforeseen repairs
- Winter variability
- Liability and lawsuits

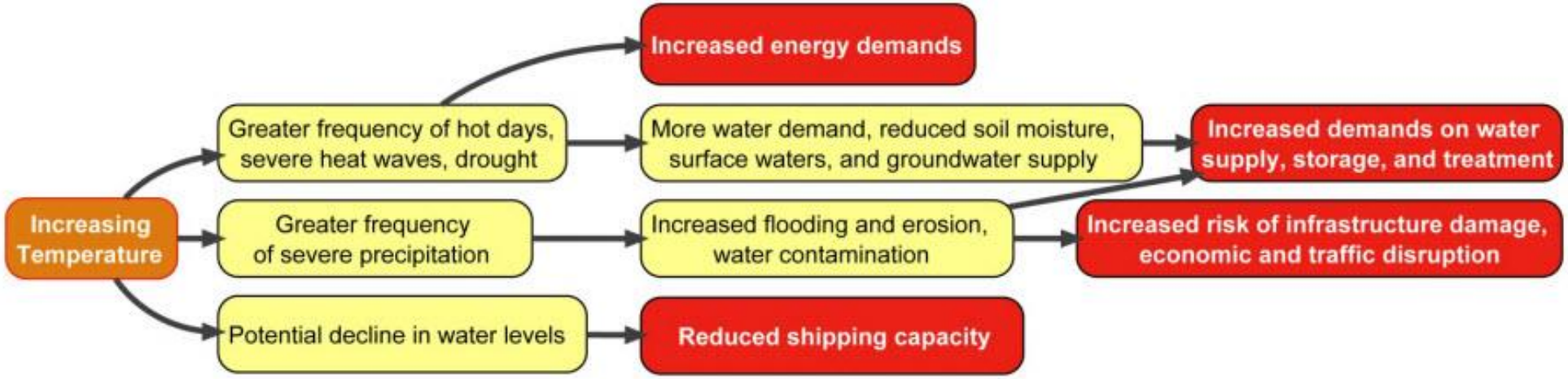
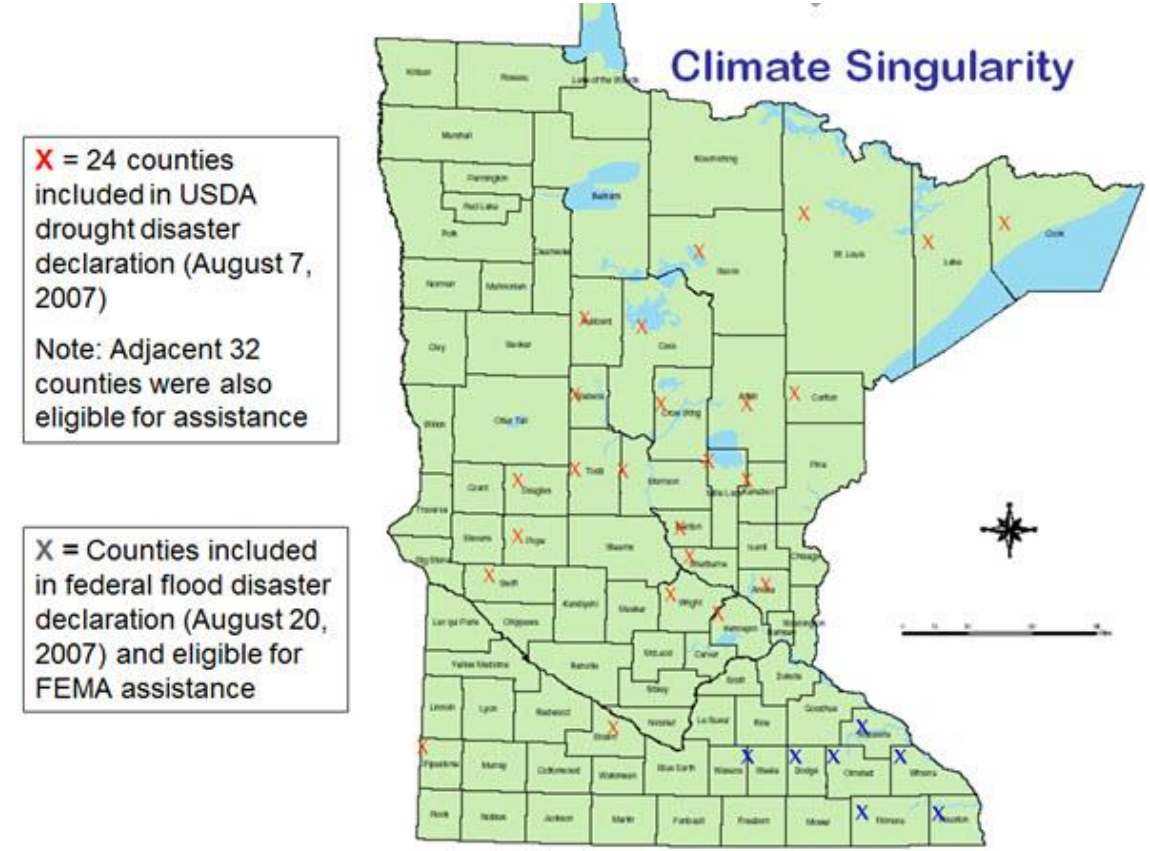


Image source: GLISA/HRWC Infrastructure Impacts Fact Sheet

Impacts on Great Lakes cities

Water quality and supply



Climate change trends point to <u>both</u> an increase in flooding and an increase in droughts.

Water quantity: Heat waves increase evaporation and water demand, potentially leading to summer shortages

Water quality: Increased stormwater runoff, lower lake levels, and warmer water → more frequent algal blooms

Water infrastructure in the Great Lakes is aging and in poor condition, increasing the risk of waterborne illness

Image source: Mark Seeley. University of Minnesota Extension Climatologist

Observations and projections in the Great Lakes

Shifting opportunities and challenges


SPECIAL EDITION

TORONTO STAR

BLACKOUT

Eves declares state of emergency and warns of rolling power outages for 'weeks to come'

SPECIAL EDITION

THE GLOBE AND MAIL

Day of the blackout

It hit us, too

New Yorkers unfazed by power cut

Toronto emergency plan is triggered by Lastman

Shifting patterns of energy demand:

- Reduced heating demand/costs in winter, increased cooling demand/costs in summer
- Increased agricultural production may strain rural energy systems

New business challenges & opportunities:

- Reduced summer water availability may interfere with industrial operations
- Increased energy and raw production market volatility
- Increased insurance premiums
- Longer shipping season due to lower lake ice cover, which may eventually be offset by lower lake levels
- Longer summer tourism and construction season

Image source: blogTO, "Remembering the massive Toronto blackout of 2003"

Impacts on Great Lakes cities

Transportation

Residents of a Grand Rapids neighborhood look at a bridge washed away in April of 2013. The bridge was what connected residents from the neighborhood to main roads.

Roads & bridges:

- Extreme heat lowers lifespan of infrastructure
- Extreme precipitation may compromise routes and infrastructure

Shipping lanes:

- Likely open earlier and longer due to reduced ice cover

Lower lake levels will lead to decreased depth of navigation channels and a reduction in the maximum loads carried by vessels. For each inch of lost draft, the average 1,000 ft freighter loses $30,000 per transit (GLISA)

Image source: Emily Zoladz | Mlive.com

Impacts on Great Lakes cities

Buildings

Climate change threats include:

- Risk to building foundations due to reduced soil moisture in the summer
- Increased basement flooding
- Rising energy costs in the summer, as well as increased thermal discomfort in buildings without A/C
- Damage from high winds and severe thunderstorms
- Roof damage from ice dams created by frequent freeze-thaw cycles, rain or snow
- Accelerated concrete deterioration (due to CO_2)

Image source: MPRNews, Flooded out homeowners near Duluth face limited options a year later, Jun 2013

Impacts on Great Lakes cities

Tourism and recreation

Climate change is creating a cultural shift with the shortening of winter, new opportunities via longer summers, and challenges of beach and water quality.

Winter recreation:

- Reduced snow cover and shorter winters

Summer recreation:

- Increasing summer temperatures and a longer summer season
- Demand for beaches may increase, but…

Beach quality:

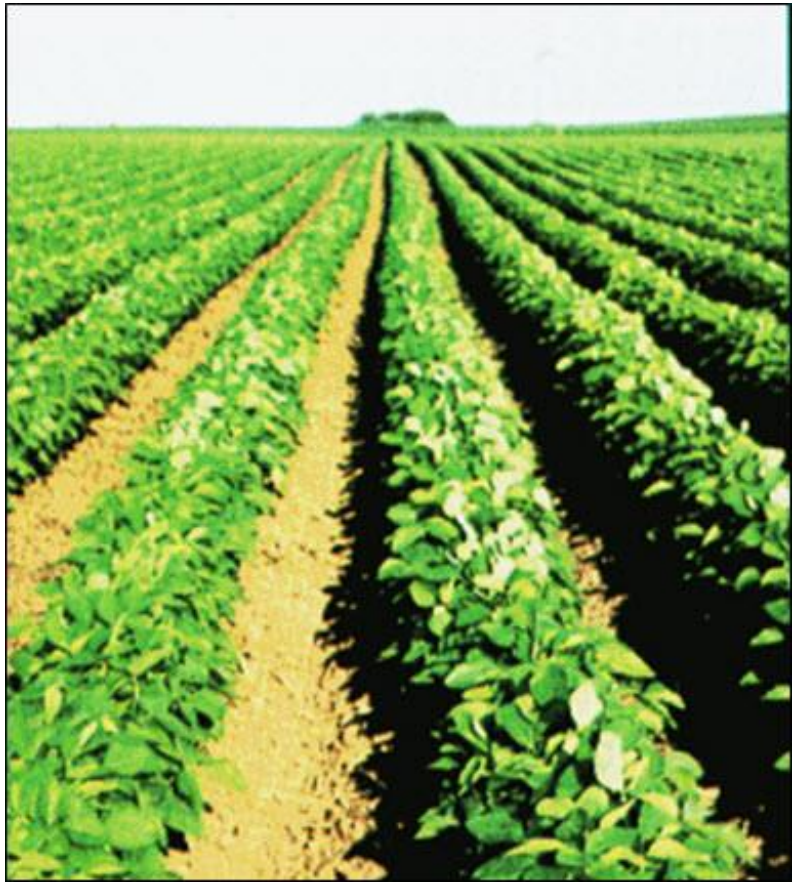
- Increased algae, decreasing lake levels, receding shorelines
- Tourist location preferences will be impacted

Fishing:

- Many coldwater species
- Warmwater populations may grow

Impacts on Great Lakes cities

Agriculture



Longer growing season:

- The frost-free season lengthened by 9 days in the Midwestern US and 10 days in the Northeast from 1958-2012 and may be up to 1-2 months longer by 2100
- Through mid-century, higher CO2 concentrations will likely also have a positive effect on many crop yields

Long term climate change effects:

By 2100, the negative effects of increasing storm activity, flooding, extreme heat, summer drought risk, and pests may outweigh the benefits of other climate changes.

Impacts on Great Lakes cities

Urban ecosystems

- Stress on vegetation from heat and drought
- Damage to parks and trees from floods and windstorms
- Loss of native biodiversity: As temperatures rise, the distribution and composition of tree species will change and shift northward
- More invasive species established
- Loss of wetlands and shorebirds

Additional Resources:

Great Lakes Climate Information

US EPA Impacts & Adaptation in the Midwest
Includes information on human health, water resources, agriculture, and ecosystems

Billion-Dollar Weather/Climate Disasters
NOAA-compiled list of climate events that have great economic and societal impacts

GLISA white papers for NCA on sectoral impacts and vulnerabilities:

- Recreation & Tourism Sector
- Water Resources Sector
- Agriculture Sector
- Coastal Sector
- Energy Sector

US Drought Monitor
Weekly map of drought conditions, produced by US government