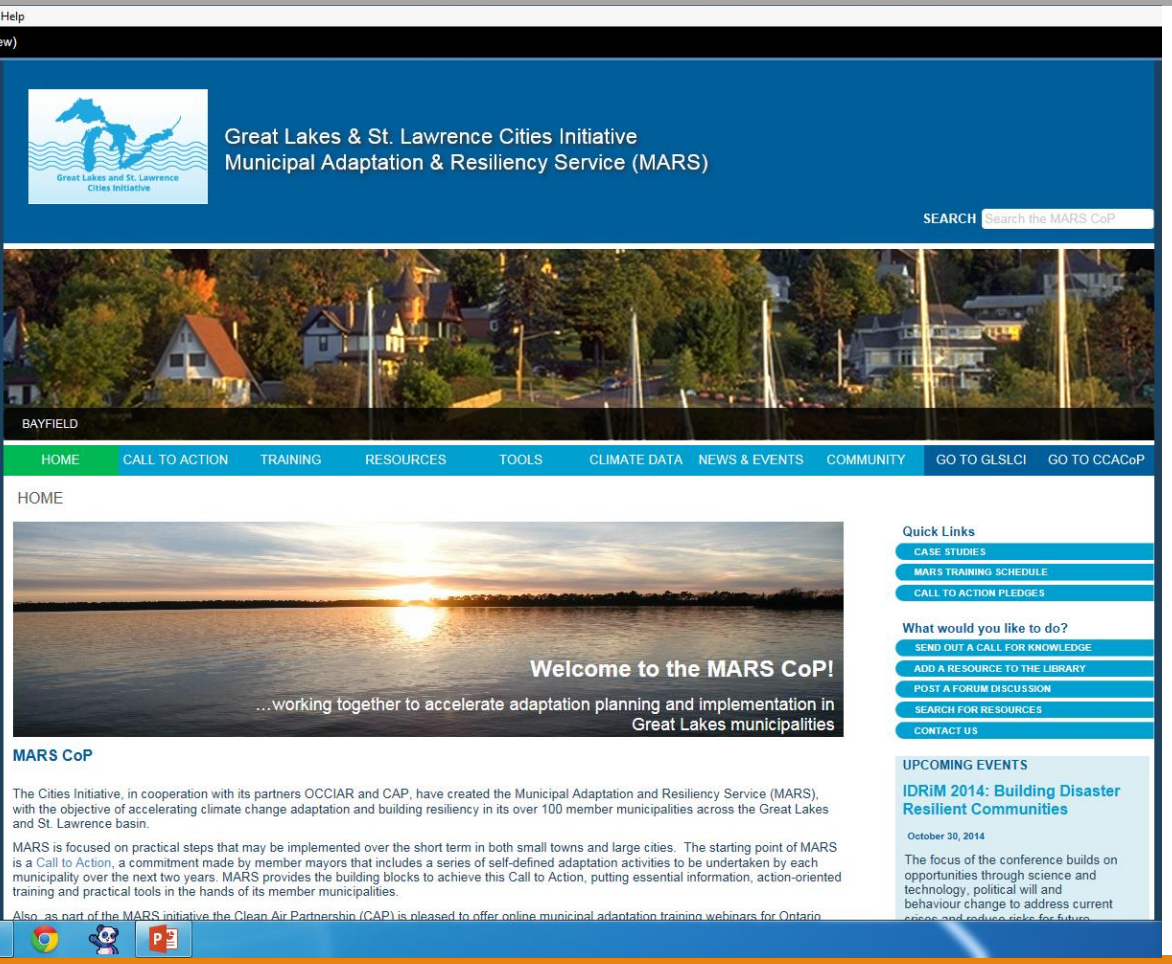
Module 1: **Climate Change and Adaptation in the Great Lakes**

Municipal Adaptation and Resiliency Service (MARS)

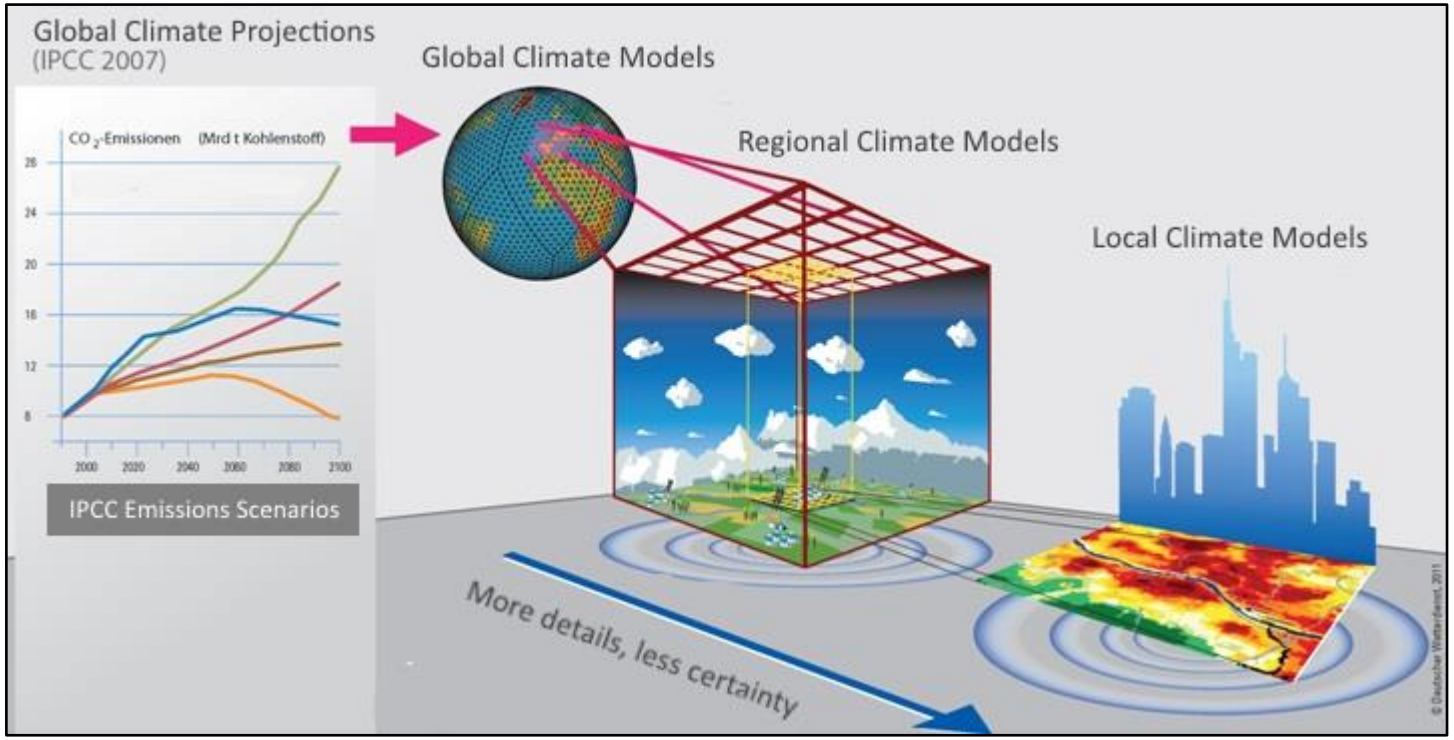


1. MARS portal and Cities Initiative MARS webpage, www.ccadaptation.ca/mars; www.glslcities.org/mars.cfm
2. Training webinar series
3. Adaptation Calls to Action
4. Climate adaptation infographics and case studies
5. Demonstration projects
6. Adaptation award at the 2015 Cities Initiative annual conference

Climate change: Global Phenomenon Local Effects

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.

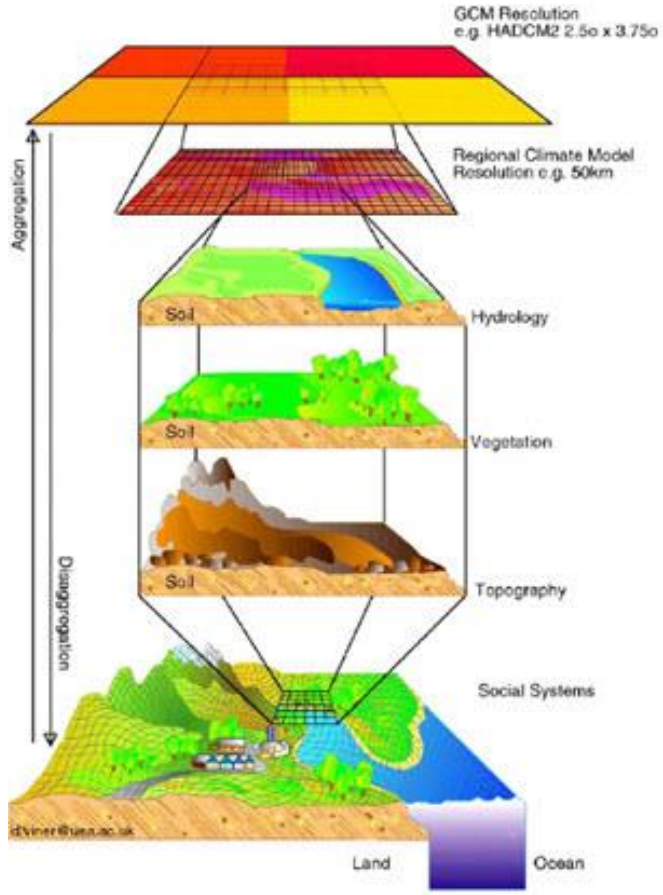
Natural variability plays a larger role at the regional scale due to changes in land use (e.g. urbanization) and geographic features (e.g. mountains and lakes).

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

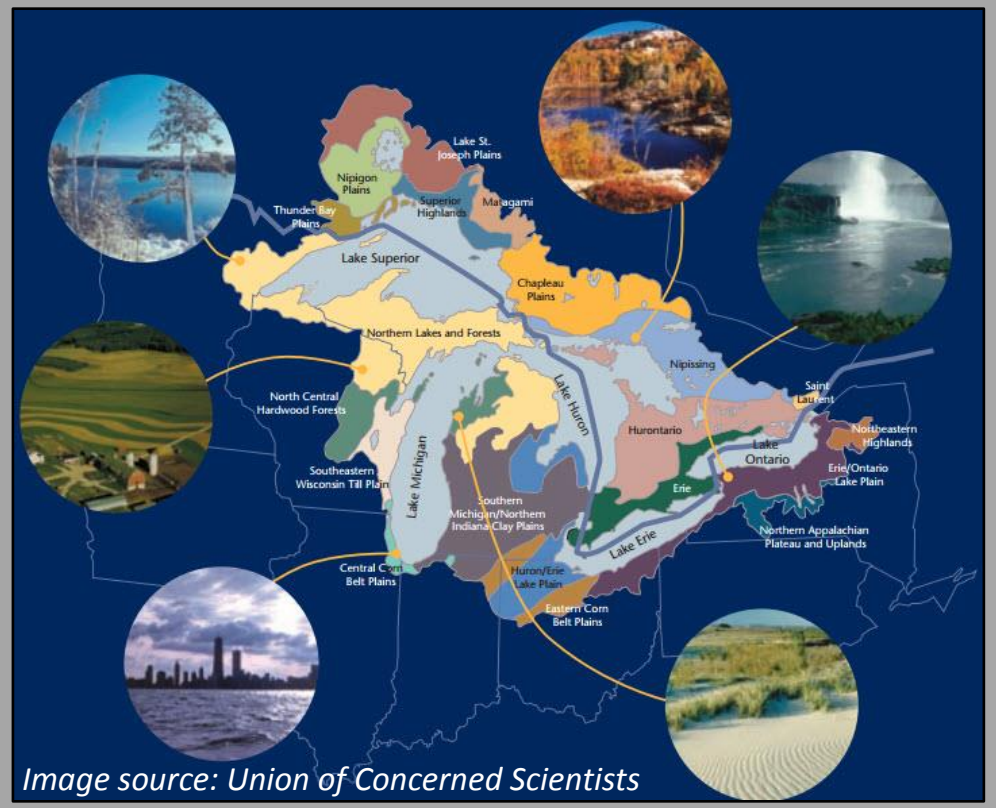


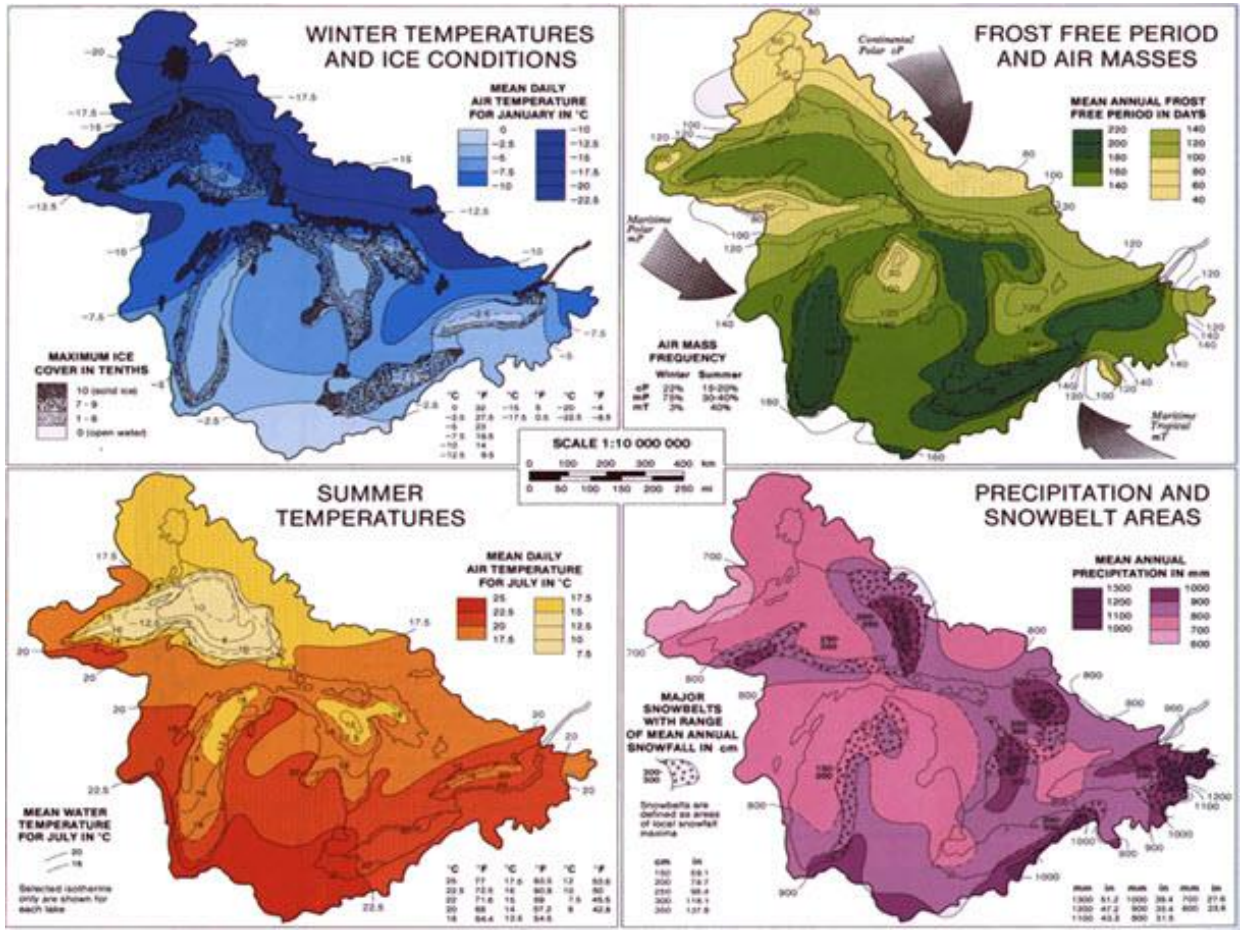
Image source: Union of Concerned Scientists

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

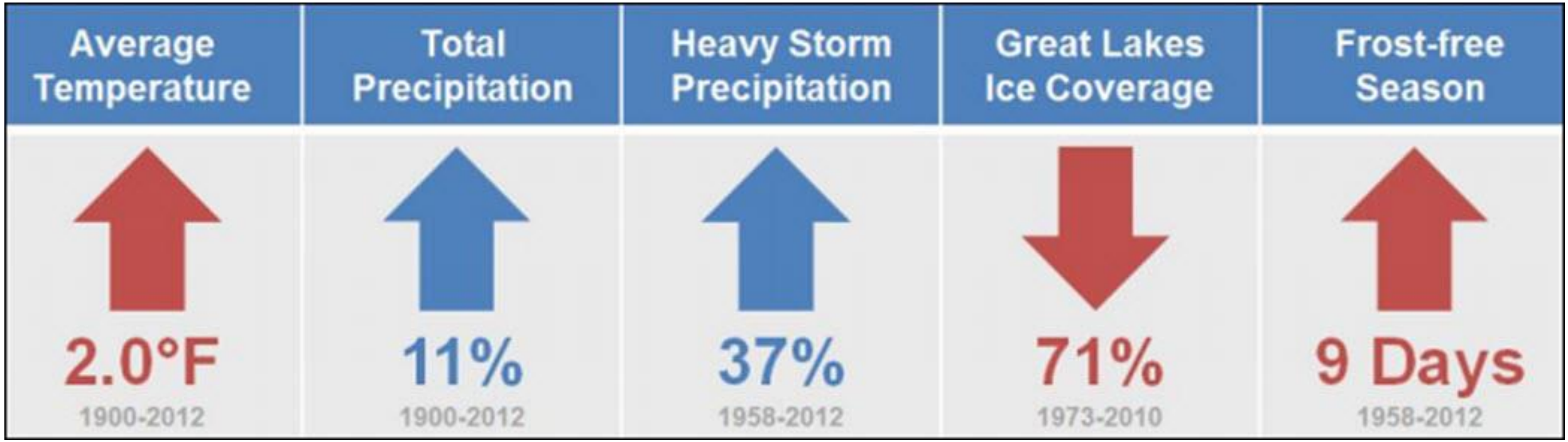


Image source: GLISA, Climate Change in the Great Lakes Region, 6/18/2014, http://glisa.msu.edu

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

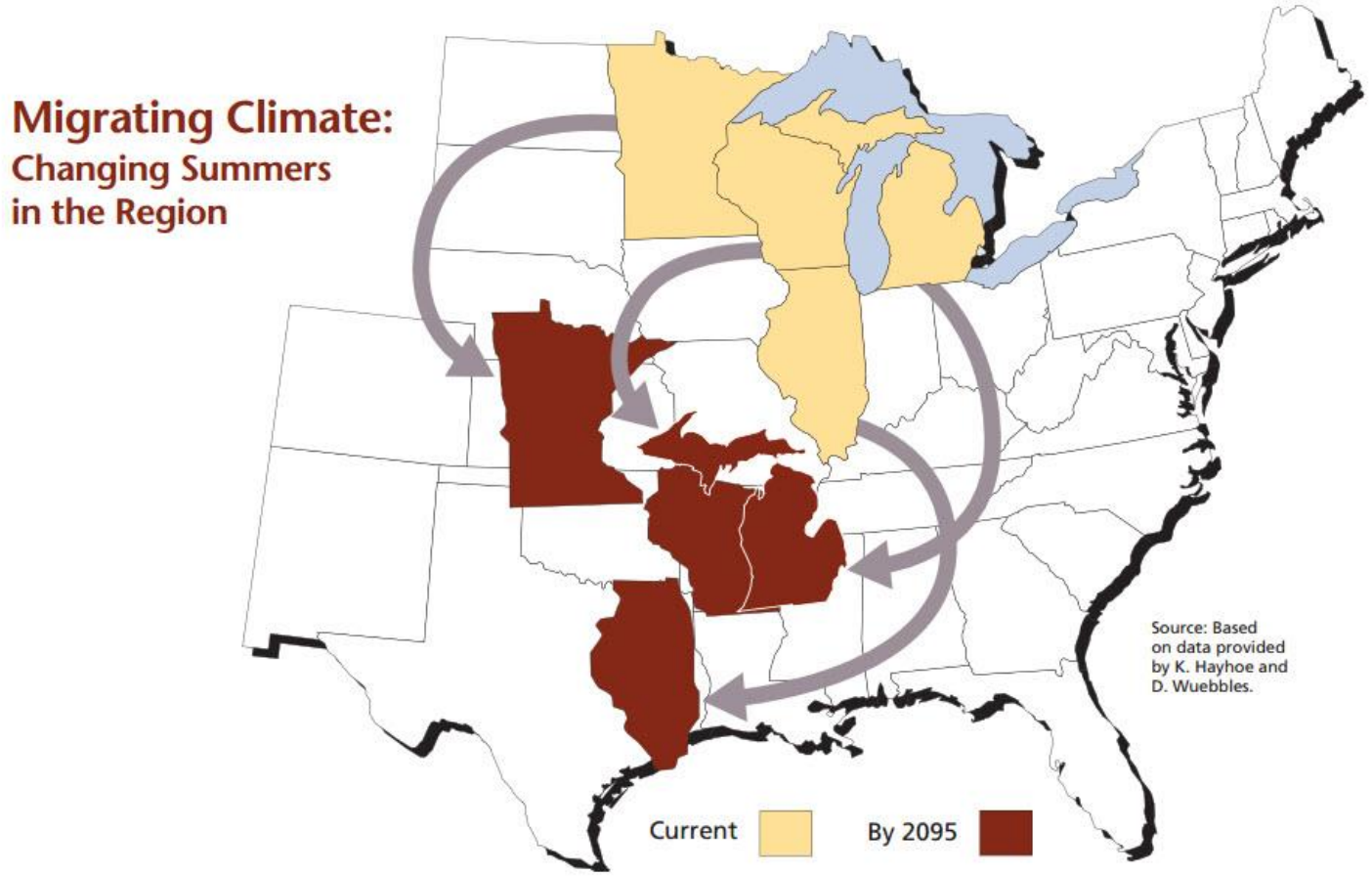
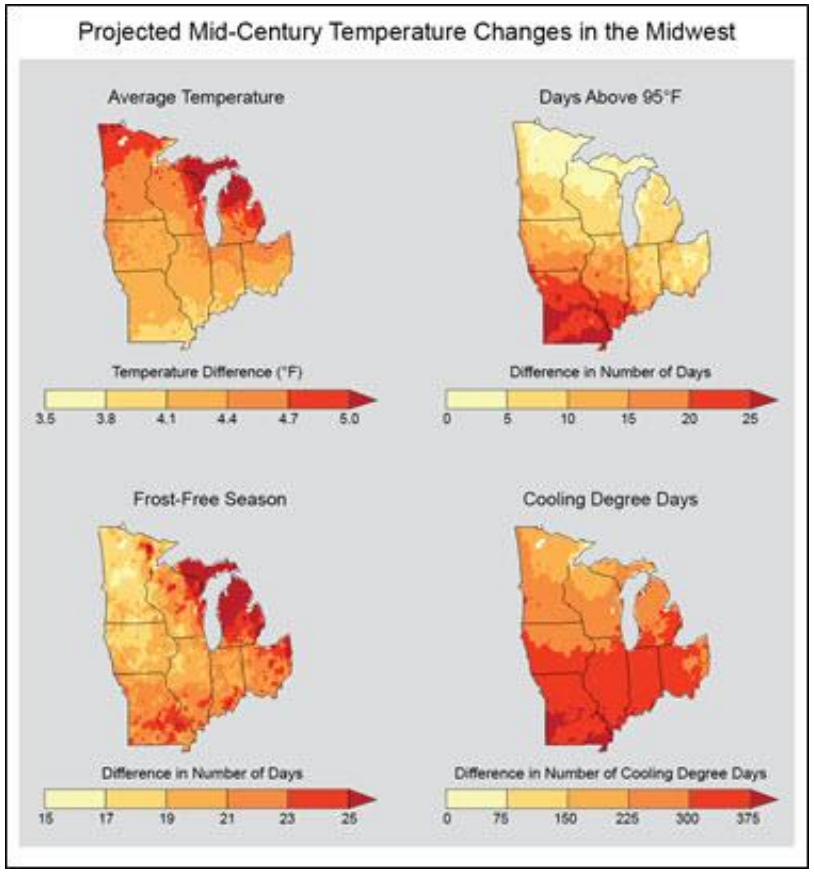


Image source: Union of Concerned Scientists, Confronting Climate Change in the Great Lakes, 2005

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.

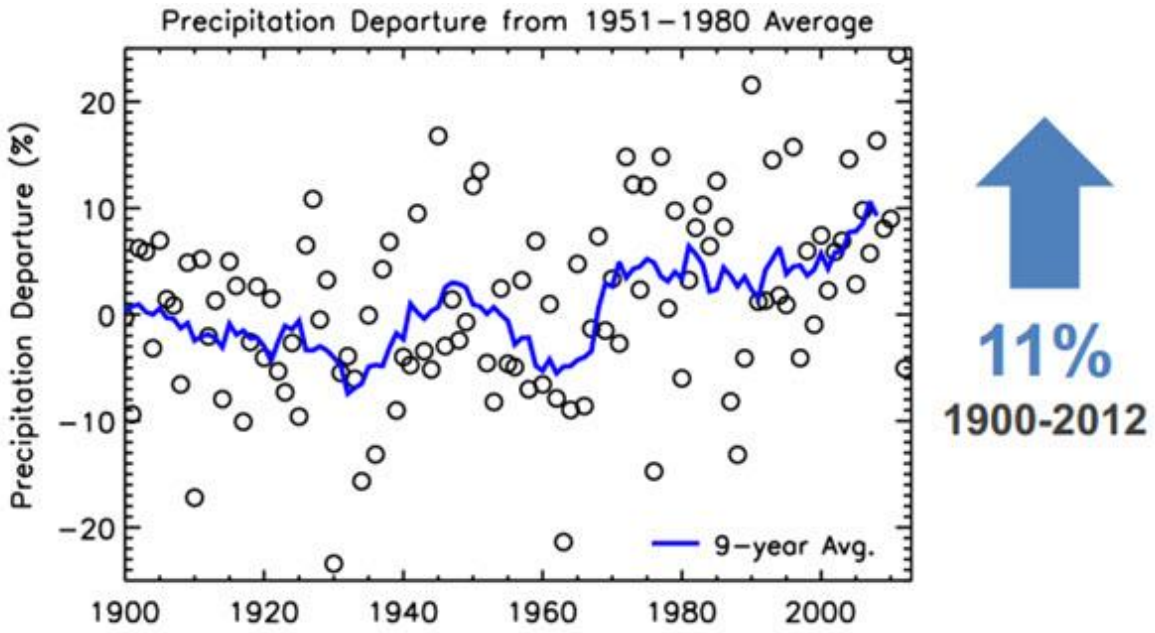
Increased extremes:
Increase in frequency of 95°F+ days

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.

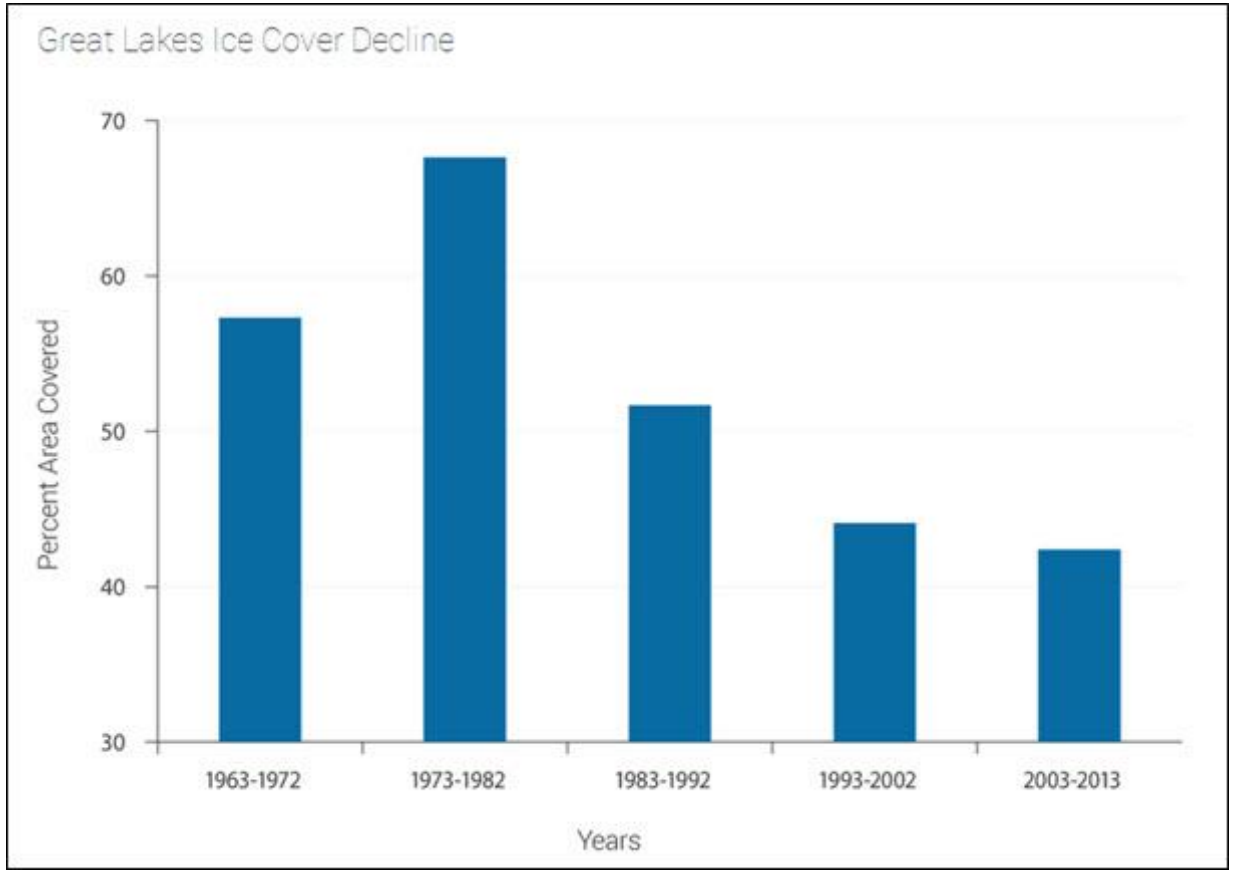
Change in seasonality:
More precipitation is falling as rain instead of snow.

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.

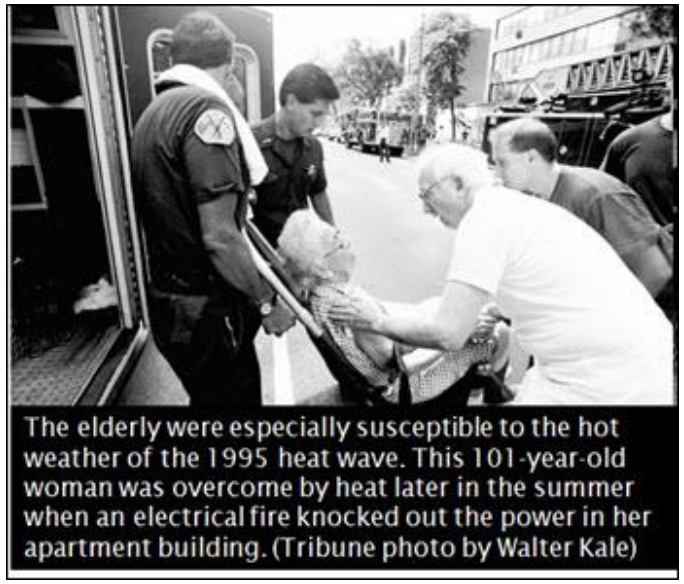
Image source: Kenneth Kunkel, Cooperative Institute for Climate and Satellites - NC

Impacts on Great Lakes Cities

THE CASE FOR ADAPTATION ACROSS MUNICIPAL SECTORS

Impacts on Great Lakes cities

Public 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:

- 2003 European heat wave: 70,000 deaths
- 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

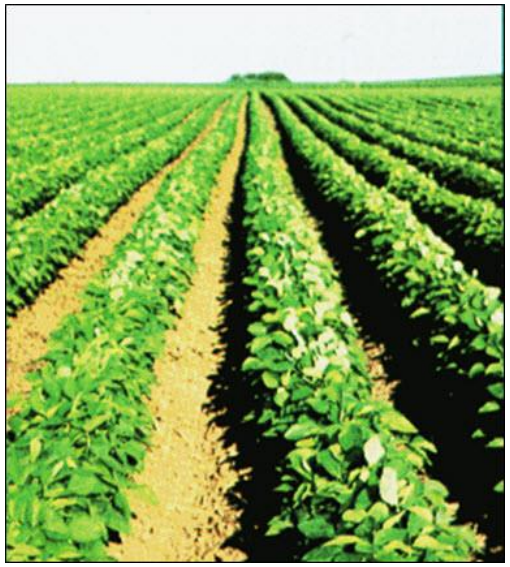
Precipitation risks:

- 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

Economic Impacts , Climate-Sensitive Sectors



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

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

Tourism, Recreation, Fishing:

- Reduced snow cover and shorter winters
- Increasing summer temperatures and a longer summer season
- Demand for beaches may increase, but…
- Increased algae, decreasing lake levels, receding shorelines
- Tourist location preferences will be impacted
- Many coldwater species
- Warmwater populations may grow

Agriculture

- Longer growing season-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
- Loss of topsoil, nutrient runoff due to severe storms

Impacts on Great Lakes cities

Government finance, Liability

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

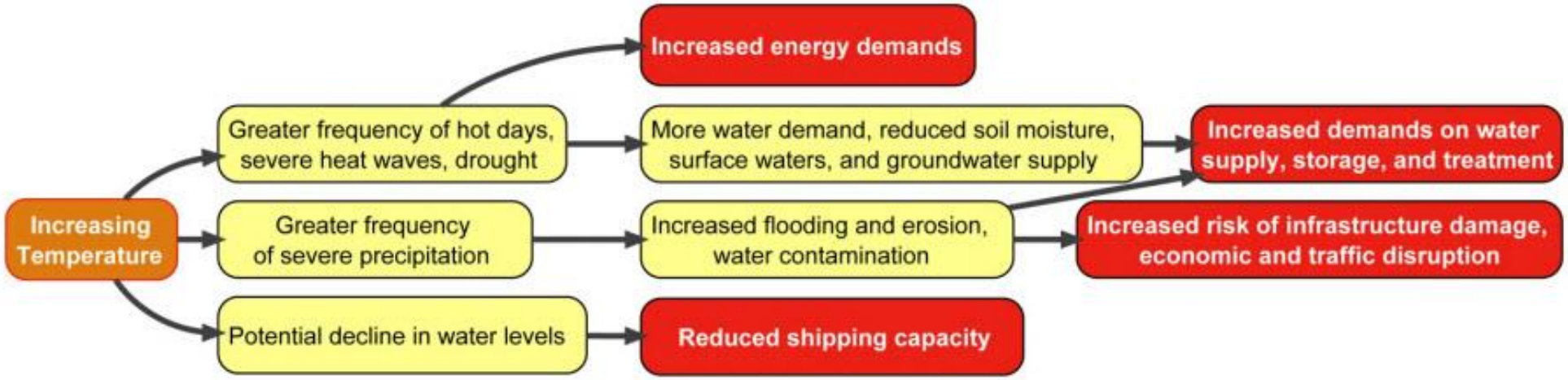


Image source: GLISA/HRWC Infrastructure Impacts Fact Sheet

Impacts on Great Lakes Cities

Resiliency of Energy, Transportation Networks

Energy:

- Reduced heating demand/costs in winter, increased cooling demand/costs in summer
- Increased agricultural production may strain rural energy systems
- Severe weather, ice storms increases vulnerability of electricity transmission, distribution
- Electricity-dependent infrastructure vulnerable during blackout, e.g. water treatment, streetcars.

Roads & bridges:

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

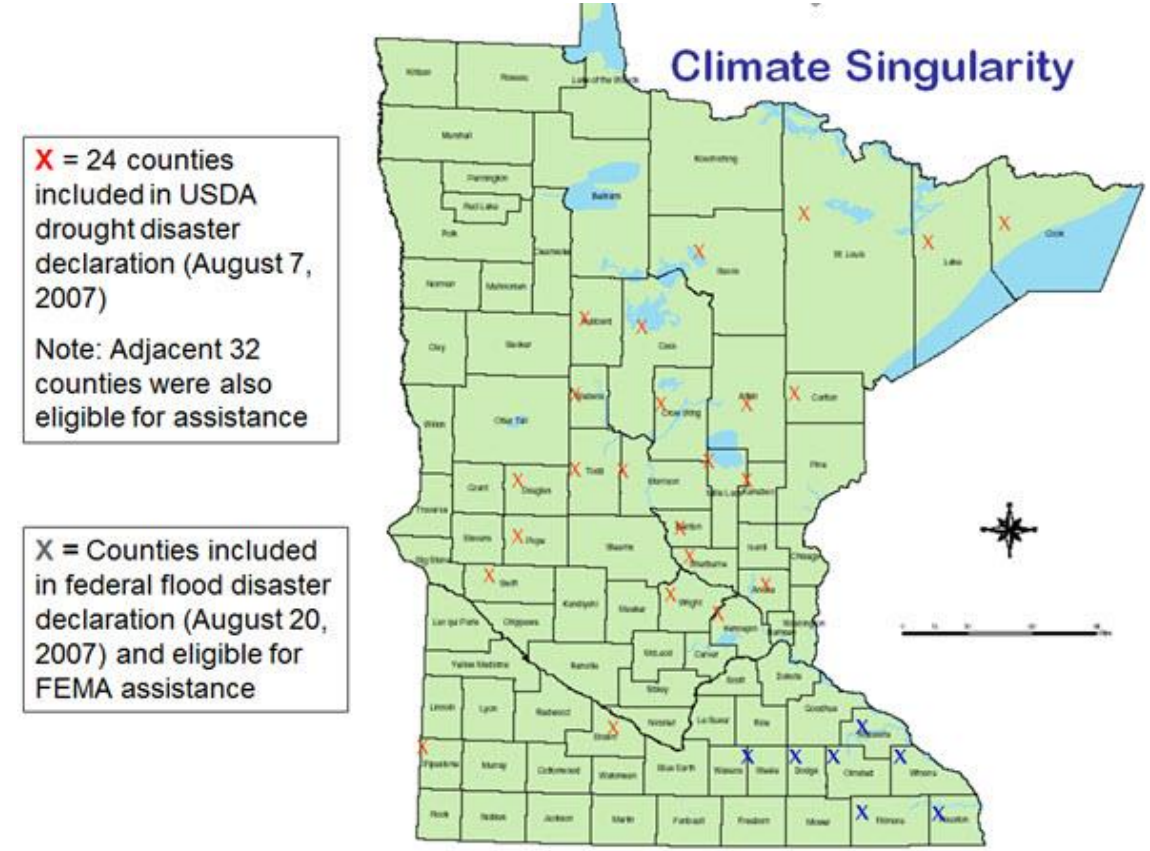
Public Transit:

Flooding of rail or other transit corridors disrupts public transit.

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

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

Impacts on Great Lakes cities

Public and private property

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

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

Municipal Adaptation and Resiliency Service (MARS)

MARS portal
www.ccadaptation.ca/mars

Cities Initiative MARS webpage
www.glslcities.org/mars.cfm

Next webinar November 19th, 11am eastern
Successful Adaptation Planning Models,
featuring Ashlee Grace, Great Lakes Adaptation for Cities (GLAA-C)
To register for upcoming webinars
www.glslcities.org/mars.cfm#current web

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

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

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