# Great Lakes Climate Change Facts: Air Temperature

**How will climate change affect air temperature in the Great Lakes region?**

## Air Temperature

**Trend:** Increasing **Certainty:** Very High

- Summers warming faster than winters
- Northeastern part of the region warming faster than the southwestern

**Climate Change Effects**

| Environmental Sector: | Impacts: |
|---|---|
| Plants and Animals | • Changes in migration routes<br>• Changes in where certain plants and animals are found and which are most common<br>• Changes in timing of seasonal events such as bird migration, fish spawning, and when plants emerge, bloom, and die<br>• Heat stress, leading to more disease outbreaks |
| Ecosystems and Habitats | • Changes in currents and upwellings in lakes<br>• Earlier stratification in lakes, meaning less mixing of oxygen and nutrients<br>• Increased risk of invasive species establishment<br>• Increase in algae blooms and dead zones<br>• Declining winter lake ice |
| Economy, Infrastructure and Health | • More pests and diseases<br>• More summer heat waves<br>• Increased damage from extreme weather events (wind, rain, and ice-storms) and storm surges |

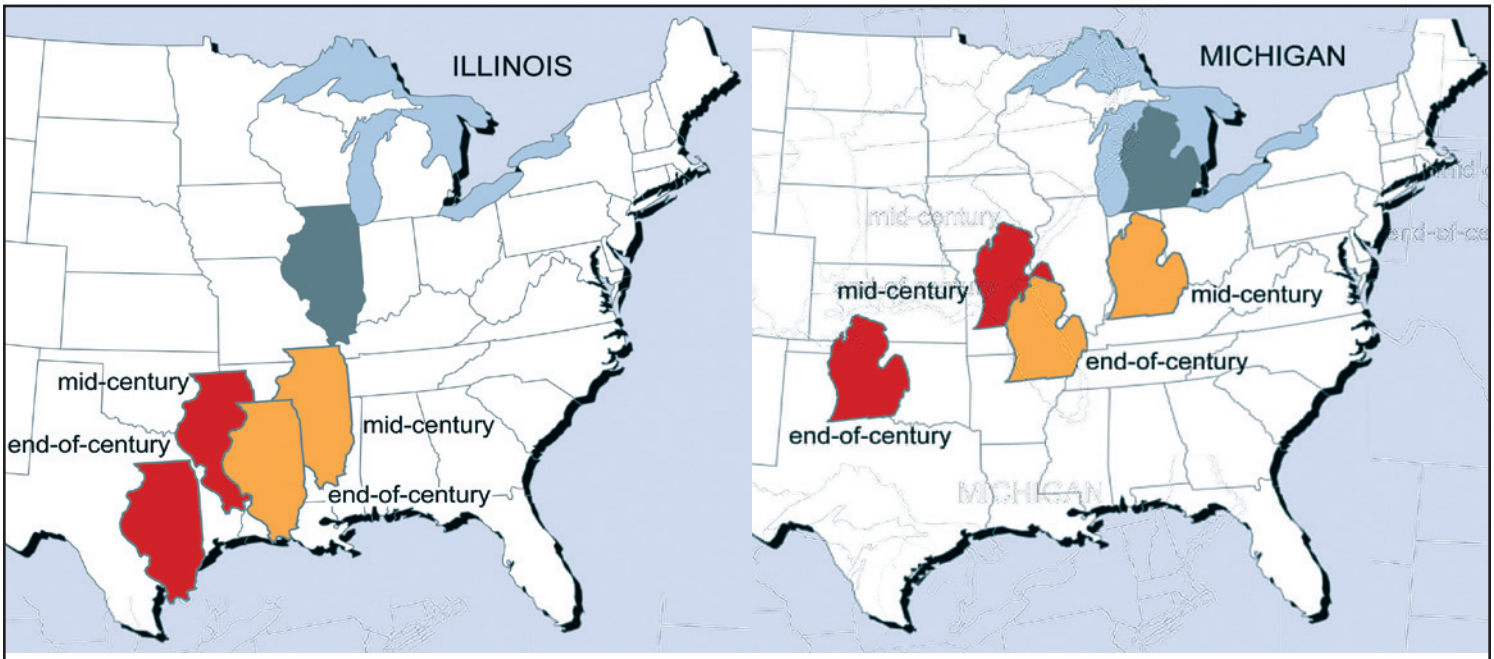
**Observed Trends:**

- The date of the last spring freeze occurs about one week earlier and the length of the growing season is about one week longer than it was in the early 20th century.
- White-footed mice, the primary reservoir for Lyme disease, have extended their ranges north by 225 km (140 miles) since 1980.

**Compounding Factors:**

- ***Changes in land use and land cover:*** Loss of tree cover increases the rate and extent of local and regional heating and drying. Extensive asphalt or other dark surfaces increases overall drying and warming.
- ***Natural climatic variations:*** Air and water temperature can also be affected by natural climate patterns, such as the El Niño-Southern Oscillation, the Pacific Decadal Oscillation, changes in the sun's solar activity, and volcanic eruptions.

# Climate on the Move

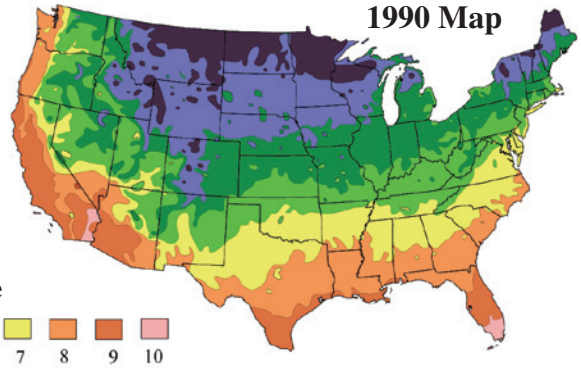



Model projections of summer average temperature and precipitation changes in Illinois and Michigan for mid-century (2040-2059), and end-of-century (2080-2099), indicate that summers in these states are expected to feel progressively more like summers currently experienced in states south and west. Both states are projected to get considerably warmer and have less summer precipitation.

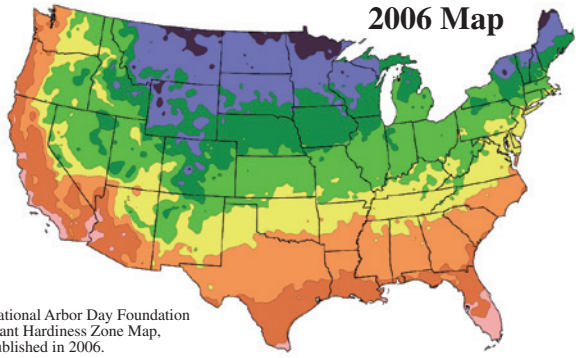
United States Global Change Research Program

## Differences between 1990 USDA hardiness zones and 2006 arborday.org hardiness zones reflect warmer climate.

After USDA Plant Hardiness Zone Map, USDA Miscellaneous Publication No. 1475, Issued January 1990.






National Arbor Day Foundation Plant Hardiness Zone Map, published in 2006.

Increasing trends in air temperature have changed the U.S. Hardiness Zones since 1990. A hardiness zone is defined by a geographical area's climatic conditions and indicates the types of plant species that will survive in the designated zone. The Arbor Day Foundation gathered data from 5,000 National Climatic Data Center cooperative stations in the U.S. to find that over the past 20 years, Hardiness Zones have changed.

The Arbor Day Foundation

# Great Lakes Climate Change Facts: Lake Levels

| How will climate change affect lake levels in the Great Lakes region? | |
|---|---|
| **Lake Levels**<br>**Trend:** Decreasing **Certainty:** Medium<br>• Slight chance of lake level increase<br>• Evaporation depends on ice cover, wind, and air and water temperature | |
| **Climate Change Effects** | |
| **Environmental Sector:** | **Impacts:** |
| Plants and Animals | • Less diverse coastal habitats and not as many kinds of fish<br>• Loss of culturally important species, such as wild rice |
| Ecosystems and Habitats | • Newly exposed lake beds overgrown by invasive species such as phragmites<br>• Remobilization of toxic chemicals previously held in the lake sediments<br>• Increased risk of harmful algal and bacterial growth in shallow lakes |
| Economy, Infrastructure and Health | • Shallower navigation channels, stranded docks, marinas, and agriculture<br>• Less water available for municipalities, industrial operations, and agriculture<br>• More health problems related to poor water quality |

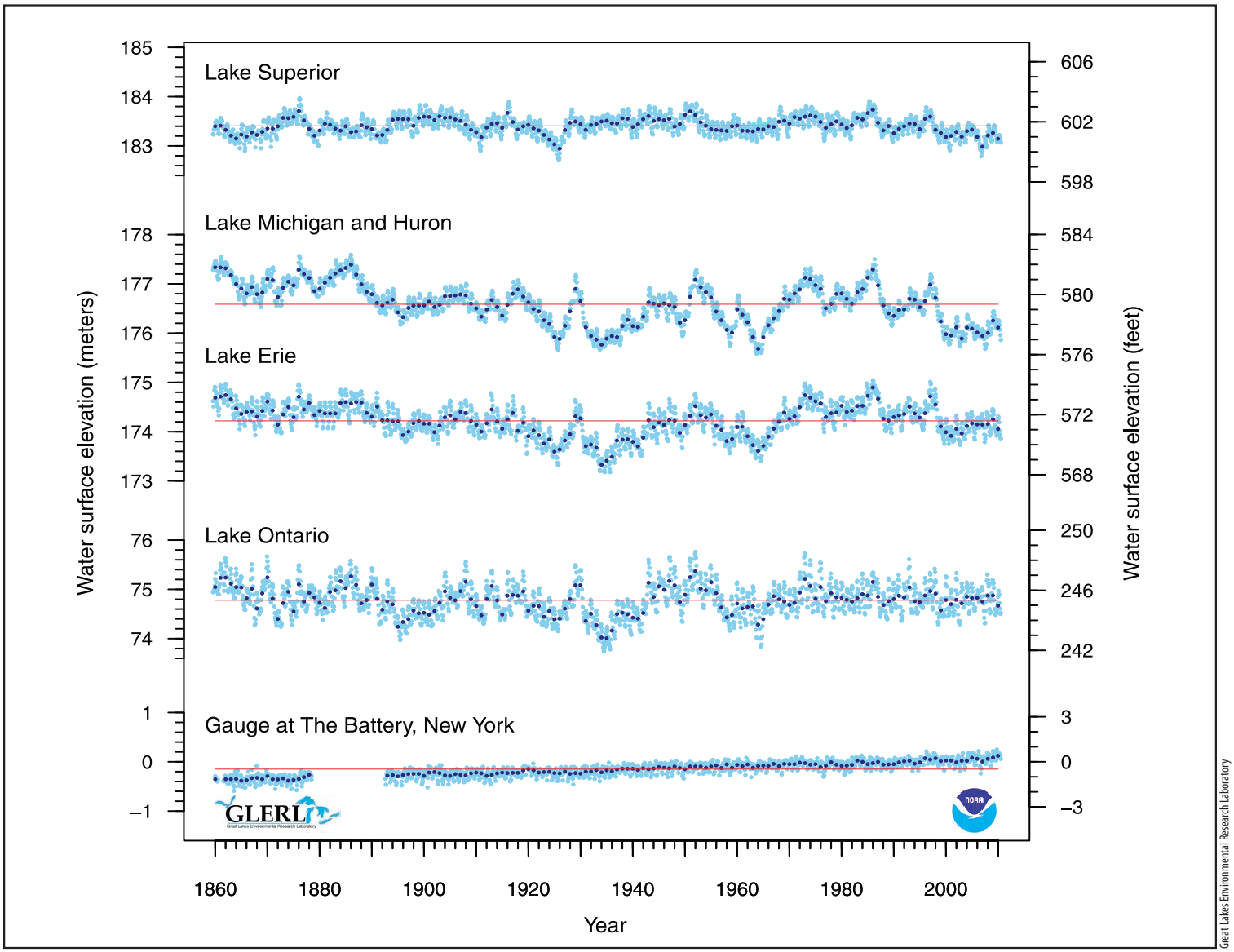
**Observed Trends:**

- Lake levels are highly variable. Lake Erie levels have varied by roughly 6 feet over the past century: its lowest levels, in 1934, were about 3 feet lower than today, while its highest levels, in 1986, were about 3 feet higher. Lakes Michigan and Huron have seen similar variations over the past century, while Lake Superior has varied by about 4 feet.

**Compounding Factors:**

- ***Water control facilities:*** The numerous dikes, locks, canals, and other water control structures throughout the Great Lakes modify water levels on local or lake-wide scales. Factors influencing decisions about water release or retention are diverse, and consider the needs of the agriculture, boating, shipping, and waterfowl hunting communities. Water outflow from Lakes Superior and Ontario is controlled by an international agreement.
- ***Natural variations:*** Many natural processes influence Great Lakes water levels over the short and long term. These include wind-driven seiches, changes in barometric pressure, seasonal changes in precipitation and evaporation, and longer-term climate variability and change.

# Water Elevation Levels, 1860-2010




The graph, “Water Surface Elevation Since 1860” charts monthly averages of lake levels, indicated by light blue dots, and yearly, indicated by black dots. The red line indicates the average level over the years monitored in the graph. For comparison, the graph also shows the sea level, measured at The Battery, New York. As shown, although the trend for the sea level is steadily increasing, lake levels are highly variable, with a decrease in the last 10-20 years.

# Great Lakes Climate Change Facts: Precipitation

## How will climate change affect precipitation in the Great Lakes region?

### Precipitation

**Trend:** Increasing **Certainty:** High

- Summers getting drier, winters and springs getting wetter
- Rainfall likely to be more intense
- The southeastern Great Lakes region may see overall decrease in precipitation
- Changes in lake-effect snow are not well predicted

**Climate Change Effects**

| Environmental Sector: | Impacts: |
|---|---|
| Plants and Animals | • Changes in bird breeding success due to increased risk of nest flooding<br>• Species better adapted to increased drought and flooding will benefit |
| Ecosystems and Habitats | • Greater risk of both flood and drought<br>• Altered runoff patterns<br>• Increased risk of invasive species establishment<br>• Fire risk may increase |
| Economy, Infrastructure and Health | • Greater conflict over water use and management<br>• Increase in sewer overflow events, releasing more untreated sewage into lakes and rivers<br>• Increased damage from extreme weather events |

**Observed Trends:**

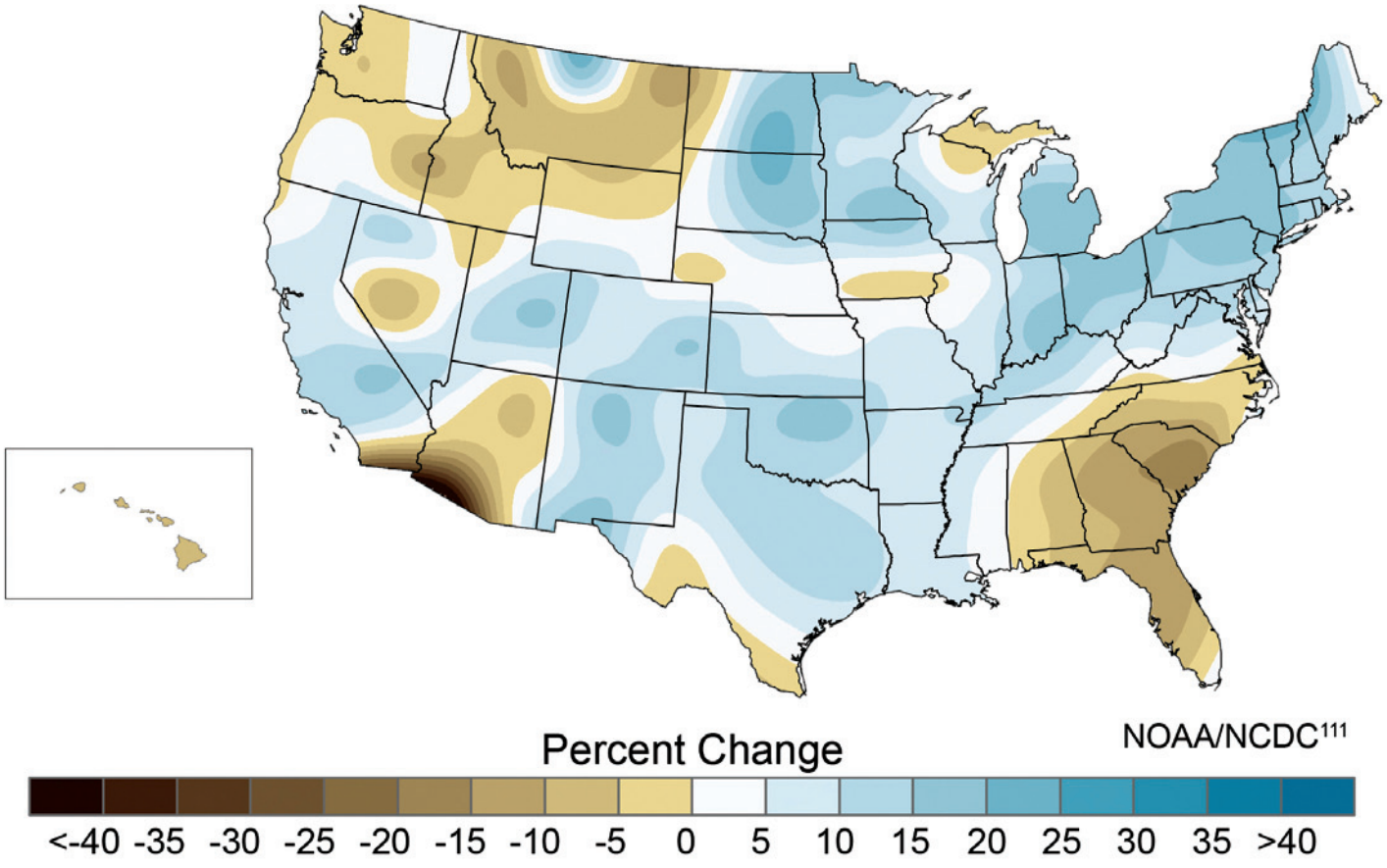
- Rainfall has increased more in autumn than any other season.
- The number of extreme weather events such as thunderstorms have been increasing over the past century.

**Compounding Factors:**

- ***Changes in land use and land cover:*** Presence of year-round tree and shrub cover reduces risk of both drought and flood. Increased development with hard surfaces (roots, pavement) can increase flood intensity and frequency as well as contributing to overall drying and warming.
- ***Natural climatic variations:*** Precipitation can also be affected by natural climate patterns, such as the El Niño-Southern Oscillation, the Pacific Decadal Oscillation, and other large-scale climate cycles.

# Change in Precipitation Across the United States in the Past 50 Years

While U.S. annual average precipitation has increased about 5 percent over the past 50 years, there have been important regional differences as shown.




National Climatic Data Center

The trend for the amount of precipitation in the Great Lakes Basin is increasing. “Change in Precipitation across the United States in the Past 50 Years” above demonstrates that although over the past 50 years the average precipitation has both increased and decreased in different geographical areas, a majority of that change has been increasing, especially in the eastern Great Lakes region.

# Understanding the Difference Between Mitigation and Adaptation

Higher concentrations of greenhouse gases in our atmosphere, whether from natural or human causes, trap more heat near Earth's surface, leading to global warming and all kinds of related changes in climate and ecosystems. Although Earth's climate has been slowly warming for several thousand years, in the past two centuries greenhouse gas emissions from human activities have skyrocketed, causing atmospheric concentrations of these gases to skyrocket, and temperatures have likewise been increasing much more rapidly than before.

We can and should slow the rate of warming by reducing greenhouse gas emissions. In addition to helping the global climate, reducing emissions can improve air and water quality, increase public health and well-being, and create new jobs. In the world of climate change, reducing emissions is referred to as ***mitigation***.

Unfortunately mitigation alone is not enough to protect us from the negative effects of climate change. Even if we stop producing greenhouse gases today, we will continue to experience a certain amount of change based on our past emissions. These changes present both risks and opportunities, and positioning ourselves to minimize the risks and take advantage of the opportunities is referred to as ***adaptation***.

The impacts of climate change—more frequent and powerful storms, floods, droughts, and heat waves and the resulting damage to people, property, and ecosystems—are already starting to affect cities, suburbs, and rural communities, lakes and rivers, forests and grasslands around the globe. To protect vulnerable communities, both human and non-human, we must develop and implement ***adaptation strategies***. Our goal is to do our best to position the places, species, and communities we care about to thrive in whatever future comes our way.

**Mitigation means reducing global climate change. Mitigation includes actions that:**

- Reduce the release of greenhouse gases into the atmosphere
- Increase the uptake and storage of greenhouse gases from the atmosphere

**Adaptation is responding to climate change impacts to limit the harm caused or take advantage of the opportunities that may arise. Adaptation includes actions that:**

- Reduce the vulnerability of humans and natural systems to climate change
- Increase the ability of natural or human systems to take advantage of climatic change

# Is It Mitigation or Adaptation?

| Examples of Mitigation Actions | Examples of Adaptation Actions |
|---|---|
| Walking, bicycling, or using public transit instead of driving | Defining floodplains based on future as well as current flood risk |
| Switching from fossil fuels to low-carbon energy sources like geothermal, solar and wind power | Using a mix of plants adapted to both flood and drought for agriculture, landscaping, or restoration |
| Replacing shingle or asphalt roofs with solar panels or green roofs | Updating water quality regulations to account for the effects of warmer, shallower lakes and rivers |
| **Examples of actions that are both!** | |
| Increasing a building's insulation reduces greenhouse gas emissions associated with heating and cooling, and also reduces the vulnerability of inhabitants to extreme heat or cold | |
| Controlling invasive pests that wipe out forests, which keeps more carbon stored in trees and also reduces the drought and flood risk associated with forest loss | |
| Using roof-top solar panels to provide some of a building's energy needs reduces greenhouse gas emissions and also makes disruption of power due to storms or excess demand during extreme heat or cold less likely | |
| Planting trees in cities soaks up carbon dioxide and provides shade and absorbs heat that reduces the risk of lethal heat waves | |

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