Climate Change in the Great Lakes Region

GLISA
A NOAA RISA TEAM

Average Temperature	Frost-free Season	Total Precipitation	Heavy Precipitation Events
			
2.3°F	**16 Days**	**14%**	**35%**
1951-2017	1951-2017	1951-2017	1951-2017

Temperature

- Since 1951, annual average air temperatures have increased by 2.3°F (1.3°C) in the U.S. Great Lakes region.
- By mid-century (2050), average air temperatures are projected to increase by 3°F to 6°F (1.7°C to 3.3°C).
- By end of century (2100), average air temperatures are projected to increase by 6°F to 11°F (3.3°C to 6.1°C).

Precipitation

- Since 1951, total annual precipitation has increased by 14% in the U.S. Great Lakes region.
- Future projections suggest more precipitation on average, but not necessarily during all seasons (summer to be drier) and not for all locations depending on which model is used.
- Reduced lake ice cover and enhanced evaporation may lead to increased lake-effect snowfall in the near-term, but rising temperatures will cause more winter precipitation to fall as rain as opposed to snow across the region by late century.

Snow, Ice Cover and Lake Temperature

- Summer lake surface temperatures have been increasing faster than the surrounding air temperatures, with Lake Superior increasing by 4.5°F between 1979 and 2006.
- Annual average ice cover on the Great Lakes underwent a shift from higher amounts prior to the 1990s to lower amounts in recent decades. There remains strong year-to-year variability, and high ice years are still possible.
- Lake-effect snowfall has increased in northern areas and may continue to increase through mid-century.

Extreme Weather

- The frequency and intensity of severe storms has increased. This trend will likely continue as the effects of climate change become more pronounced.
- The amount of precipitation falling in the heaviest 1% of storms increased by 35% in the U.S. Great Lakes region from 1951 through 2017.
- More severe storms may have a negative economic impact due to resulting damages and increased costs of preparation, clean up, and business disruption.

Water Quality and Stormwater Management

- Projected increases in droughts, severe storms, and flooding events may amplify the risk of erosion, sewage overflow, interference with transportation, and flood damage.
- Future changes in land use could have a far greater impact on water quality than climate change. The coupling of climate change and land use change could therefore result in even stronger effects in some areas.

Lake Levels

- Water level fluctuations on the Great Lakes are mainly driven by precipitation, evaporation, and runoff, which make up the lakes' net basin supply.
- After a period of low lake levels lasting from the 1990s to the mid-2010s, the lakes have risen at an unprecedented rate since 2014. This contributed to record high levels on Lake Ontario, which caused widespread flooding in 2017.
- Modeling of future lake levels is continually being updated and improved. Currently, the strongest evidence indicates increasing variability in lake level fluctuations.

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Algal Blooms

- Warmer surface water temperatures increase stratification of the lakes and decrease vertical mixing.
- Stronger storms and the use of impervious surfaces increase runoff and nutrient loading to the Great Lakes.
- Combined sewer overflows and agricultural fertilizers are major contributors to high nutrient loads.
- Stronger storms, warmer temperatures, and nutrient loading contribute to the formation of harmful algal blooms and hypoxic dead zones.

Fish and Wildlife

- The rate of warming may outpace the rate at which ecosystems are able to migrate and adapt.
- Wildlife populations better adapted to cold temperatures will continue to decline as competing species migrate into the region with rising temperatures.
- Lake stratification and hypoxic conditions will further stress biomass productivity in lakes and wetlands.
- Increased evaporation rates and sustained levels of high or low water levels may change wetland areas in the region.

Water Availability

- Despite increasing precipitation, land surfaces in the Great Lakes region are expected to become drier overall due to increasing temperatures and evaporation rates.
- More frequent summer droughts could affect soil moisture, surface waters, and groundwater supply.
- The seasonal distribution of the water cycle will likely change. Warmer temperatures may lead to more winter rain and earlier peak streamflows.

Forests

- As temperatures rise, the distribution and composition of tree species will change and shift northward.
- With warmer temperatures and increasing CO_2, forest productivity will likely increase until other impacts of climate change, such as increased drought, fire, and invasive species present additional stressors to forests.

Energy and Industry

- Reduced summer water availability may interfere with some industrial operations (i.e., hydropower, thermoelectric and nuclear plant cooling).
- Warmer temperatures and more frequent heat waves will likely increase electricity demands, particularly in urban areas and during summer months.

Agriculture

- The frost-free season lengthened by 16 days in the Great Lakes region from 1951-2017, and may extend up to 50 days longer by 2100.
- In the near-term, a longer growing season and higher CO_2 concentrations will likely have a positive effect on crop yields.
- In the long-term, the negative effects of increasing storm activity, flooding, extreme heat, summer drought risks, and pests may outweigh the benefits of warmer climates.

Transportation

- More extreme heat may increase the risk of heat damage to pavement and railroads.
- More extreme precipitation may compromise transportation routes and damage infrastructure.
- Shipping lanes will likely be open earlier and longer due to reduced ice cover on the Great Lakes.
- Low lake levels can affect navigation channels and reduce the maximum loads carried by vessels, which amount to substantial monetary losses per transit.

Public Health

- Increased risk of heat waves and increased humidity may amplify the number of heat-related deaths and illnesses.
- More storm activity and flooding will likely increase the risk of watershed contamination and water-borne illnesses, while warmer surface waters amplify the risk of toxic algal blooms and fish contamination.

Tourism and Recreation

- Winter recreation and tourism are likely to suffer due to reduced snow cover and shorter winters.
- Increased lake contamination from algal blooms may degrade shoreline water quality and coastal ecosystem health, but increasing summer temperatures and a longer summer season may increase demand for beaches.
- Overall, summer tourism may grow before temperature rise becomes unfavorable for many recreational activities.
- Many coldwater species of fish important to recreation (i.e., whitefish and lake trout) are likely to decline while populations of warm water species are likely to grow.

Further explanation and references for reported trends and statements are available at:
glisa.umich.edu/gl-climate-factsheet-refs