



Air Temperature

Overall Assessment

Trend: Increasing

Rationale: Unavailable

Purpose

- To assess trends in air temperature and to examine the observed evidence and effects of climate changes in and on the Great Lakes region.

Ecosystem Objective

The Great Lakes Water Quality Agreement Act's General Objectives state, "these water should be free from materials and heat directly or indirectly entering the water as a result of human activity that...produces conditions that are toxic or harmful to human, animal, or aquatic life." Furthermore, this indicator relates to Annex 1 of the Great Lakes Water Quality Agreement which states, "there should be no change in temperature that would adversely affect any local or general use of the waters."

Ecological Condition

Trends

According to the Intergovernmental Panel on Climate Change's (IPCC) 2007 Synthesis report, "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." This finding is supported in part by global temperature data showing that of the last twelve years (1995-2007), eleven were among the warmest in the instrumental record of global surface temperature dating back to 1850 (*Bernstein et al., 2007*). At the local and regional scale climate data can be naturally quite variable (*Kling et al., 2003*). As a result, the identification of the contribution of anthropogenic warming within long-term trends on this scale can be problematic. As most changes in the Great Lakes region are still within the bounds of natural variability, it can be difficult to definitively attribute observed trends to human induced climate change. Nevertheless, the similarity between regionally and globally observed trends supports a connection between observed changes in the basin and climatic shifts (*Hayhoe et al., 2009*).

Based on the analysis of data from the National Climate Data Center (1985-2001) and the Midwest Climate Center (1900-2000) of the Great Lakes region, over the last thirty years, temperatures have hovered near or slightly above long-term averages. The data also suggests a recent shift in temperature. In the last four years the annual average temperatures have ranged from 2 to 4°F (1 to 2°C) warmer than the long-term average with up to a 7°F (4°C) increase above average in the winter. It is important to note, however, that this warming is comparable in magnitude to warm periods experienced during the 1930s and 1950s. Furthermore, the hottest months in history have occurred in the past two decades and most years have been characterized by a decrease in cold waves (*Kling et al., 2003*).

Based on the predictions of climate models, temperature in the region are expected to warm by 5 to 12 °F (3 to 7°C) in the winter months and by 5 to 20 °F (3 to 11°C) in the summer months. Examining the data at a finer resolution, models also suggest a larger increase in night-time temperatures than daytime temperatures and an increase in extreme heat events (*Kling et al., 2003*).

Data Source

Data from this report was generated using climate data from the NOAA climate divisions found in Table 1. These divisions were chosen based on an approximation of the boundaries of the Great Lakes basin.

Linkages

According to findings from the IPCC, "there is high confidence that recent regional changes in temperature have had discernable impacts on physical and biological systems." In this report, the term 'high confidence' is characterized by an 8 out of 10 chance of being correct. Furthermore, there is 'very high confidence' (characterized by at least a 9

out of 10 chance of being correct) that species within terrestrial biological systems have already been strongly affected by earlier timing of spring events, bird migrations, and egg-laying, and poleward and upward range shifts in plant and animal species. With regard to freshwater systems, there is 'high confidence' that observed changes in aquatic biological systems are associated with increases in water temperature and, subsequently, related to alterations in ice cover, oxygen levels, and circulation. Observed changes include increases in algal and zooplankton abundance in high latitude lakes and range changes and temporal shifts in fish migration patterns (*Bernstein et al., 2007*). This assessment is reflected in the Great Lakes region through trends indicating an earlier occurrence of the last spring freeze, to the magnitude of one week earlier than was experienced at the beginning of the 1990s, and a lengthening of the growing season over the past two decades (Kling et al., 2003).

Additional observed changes include:

- Declines in the duration of winter ice (see *Ice Duration Report*)
- Increases in surface water temperatures and a corresponding increase in the duration of the period of summer stratification (see *Surface Water Temperature Report*) (Kling et al., 2003)
- Alterations of patterns of precipitation (see *Extreme Precipitation Indicator Report*)
- The time in which plants bloom has been altered on the magnitude of two weeks earlier than in the early- to mid- 1900s (Glick, 2011)

Additional expected changes include:

- Reduction in coldwater species such as lake trout, brook trout, and whitefish and cool-water species such as northern pike and walleye in southern parts of the basin. Conversely, the distribution of warm water fish such as smallmouth bass and bluegill are likely to expand northward
- Increased likelihood of invasions from warm-water non-native species
- Altered timing of hydrologic flows characterized by increased variability in timing, frequency, and duration of events
- Altered distribution of plant distribution likely characterized by a northward shift in forest communities
- Range shifts in insect species including such forest and agricultural pests as gypsy moths and bean leaf beetles (Kling et al., 2003)

Management Challenges/Opportunities

The realm of response options to address climate change is classified into two categories, the first of which is adaptation, or "initiatives and measures designed to reduce the vulnerability of natural and human systems against actual or expected climate change effects" (Koslow, 2010). Although a wide range of adaptation strategies exist, there are significant financial, technological, cognitive, behavioral, political, social, institutional, and cultural constraints resulting in limited implementation and effectiveness of adaptive strategies. Such limitations are apparent even in countries with high adaptive capacity as was showcased by the 2003 heat wave in Europe that resulted in significant human mortality, especially among the elderly population (Bernstein et al., 2007).

In the Great Lakes basin there has been significant progress in defining what adaptation means for conservation and restoration efforts in the region. For example, tools to help managers incorporate adaptation strategies into planning efforts have been developed by such organizations as the National Wildlife Federation, the Climate Adaptation Knowledge Exchange, regional Sea Grant offices, NOAA, and Natural Resources Canada to name a few (Koslow, 2010 and Natural Resources Canada). A few examples of projects or programs which have integrated adaptive strategies into management processes include the following:

- The Great Lakes-St Lawrence River Basin Water Resources Compact: The Compact is a law that required withdrawal standards be reviewed to, "give substantive consideration to climate change or other significant threats to Basin Waters and take into account the current state of scientific knowledge, or uncertainty, and appropriate measures to exercise cause in cases of uncertainty if serious damage may result" (Koslow, 2010).
- City of Grand Rapids, Michigan: In the City, in order to adapt to changes in temperature, there is a plan to increase the percentage of tree canopy to reduce the urban heat island effect and thus the impact on human and ecological health from heat events (Koslow, 2010).

Despite relatively recent advances in the field of climate adaptation, there exist several limitations which present

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barriers to progress. In 2011, the National Wildlife Federation and the National Council for Science and the Environment convened a meeting of 80 natural resource and climate change experts. These respondents included representation from federal agencies, state agencies, tribes, and non-profit organizations. Findings from this summit highlighted the current need for funding, downscaled climate information, planning guidance for adaptation projects, guidance on project implementation, and case studies of on-the-ground adaptation efforts (Inkley, 2011). These findings mirror those of the 2010 workshop, organized by the National Wildlife Federation, the Great Lakes Commission, and the Council of Great Lakes Industries which drew representation from states and cities, federal agencies, Canada, the International Joint Commission, industry, environmental non-governmental groups, First Nations, Tribes, and academic institutions titled Climate Change in the Great Lakes: Advancing the Regional Discussion (Hinderer, 2010). Findings from this meeting suggest the need for the following actions to overcome barriers to success:

- Increased application of climate science in on-the-ground restoration and protection efforts such as wildlife management, habitation restoration, and urban planning.
- Increased focus on building cross-sector partnerships to increase knowledge sharing
- Place increased emphasis quality of life improvement from climate change adaptation in order to better inform the public of the need and benefits of such actions
- Increased use of economic incentives to increase the use of adaptive strategies (Hinderer, 2010)

The other way in which climate change can be addressed is through mitigation, or technological change and substitution that reduce resource inputs and emissions per unit of output (Koslow, 2010).

Both mitigation and adaptation strategies are necessary to lessen the future impacts of climate change. However, there is ‘high confidence’ that neither adaptation nor mitigation can eliminate all threats. Furthermore, in a scenario of unmitigated climate change, in the long-term it is likely that the capacity of the world’s natural, managed, and human systems to adapt will be severely limited. In other words, sole reliance on adaptation to address the impacts of climate change may result in the creation of a world in which the magnitude of the effects of climate change grow to the extent in which human and natural populations are either unable to adapt or confronted with solutions with very high social, environmental, and economic costs (Bernstein et al., 2007).

Assessing Data Quality

Insert “x” under the statement that best corresponds with each data characteristic

Data Characteristics	Strongly Agree	Agree	Neutral or Unknown	Disagree	Strongly Disagree	Not Applicable
1. Data are documented, validated, or quality-assured by a recognized agency or organization	x					
2. Data are traceable to original sources	x					
3. The source of the data is a known, reliable and respected generator of data	x					
4. Geographic coverage and scale of data are appropriate to the Great Lakes basin		x				
5. Data obtained from sources within the U.S. are comparable to those from Canada						x
6. Uncertainty and variability in the data are documented and within acceptable limits for this indicator report	x					
Clarifying Notes:						

Acknowledgments

Author: Sarah Neville, ORISE Research Fellow Appointed to the U.S. Environmental Protection Agency Great Lakes National Program Office

Contributors: Deke Arndt, Chief, Climate Monitoring Branch, National Oceanic and Atmospheric Administration

Information Sources

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Kling, G., Hayhoe, J., Magnuson, J., Robinson, S., Shuter, B., Wander, M., et al. (2003). *Confronting Climate Change in the Great Lakes region: Impacts on Our Communities and Ecosystems*. Union of Concerned Scientists and the Ecological Society of America.

Koslow, M. (2010). *Improving the Odds: using Climate-Readiness Planning to Reduce the Impacts of Climate Change on the Great Lakes Ecosystem*. National Wildlife Federation.

List of Tables

Table 1. NOAA Climate Divisions

Source:

List of Figures

Figure 1. Trends in Air Temperature in the Great Lakes Basin.

Source:

Last Updated

State of the Lakes Ecosystem Conference (SOLEC) 2011

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State	Climate Division
Minnesota	3,6
Wisconsin	1,2,3,6,9
Illinois	2
Indiana	1,2,3
Michigan	1,2,3,4,5,6,7,8,9,10
Ohio	1,2,3,4
Pennsylvania	10
New York	1,9,10

Table 1. NOAA Climate Divisions

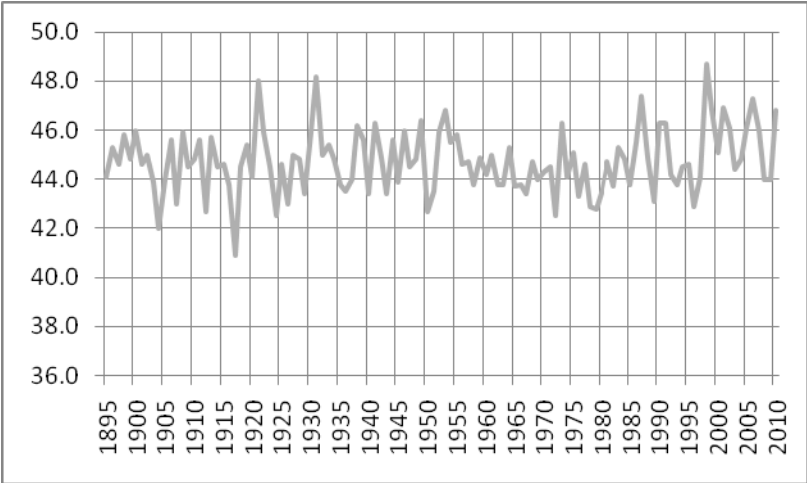


Figure 1. Trends in Air Temperature in the Great Lakes Basin.

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