Historical and Projected Future Climatic Trends in the Great Lakes Region

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Flooding along I-696
Warren, MI
11 August, 2014
Outline

• Historical Trends
• Climatic Variability/Extreme Events
• Future Projections
Historical Trends
Land & Ocean Temperature Percentiles Jan–Dec 2016
NOAA's National Centers for Environmental Information
Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0
Global Temperature Summary

• The average global temperatures across land and ocean surface areas for 2016 was 0.94°C (1.69°F) above the 20 century average of 13.9°C (57.0°F), and 2016 is new warmest year on record (137-year series). Eight consecutive high monthly temperature records were set from January to August, 2016. This is the third consecutive year a new global annual temperature record has been set.
• Global temperatures in 2016 were influenced by strong El Niño conditions that prevailed at the beginning of the year.
• This marks the fifth time in the 21 century a new record high annual temperature has been set (along with 2005, 2010, 2014, and 2015) and also the 40 consecutive year (since 1977) that the annual temperature has been above the 20 century average.
• To date, all 16 years of the 21 century rank among the 17 warmest on record and the 5 warmest years have all occurred since 2010.
• Average 2016 Arctic and Antarctic sea ice extent were 3.92 million mi² and 4.31 million mi², the smallest and 2nd smallest on record, respectively.
• Overall, the global annual temperature has increased at an average rate of 0.07°C (0.13°F) per decade since 1880 and 0.17°C (0.31°F) per decade since 1970.

(Source: NOAA/NCEI, 2017)
Annual Temperatures vs Year, Michigan
1895-2016
Changes in the Length of the Frost Free Season
Great Lakes Region

![Graph showing changes in the length of the frost free season in the Great Lakes Region from 1895 to 1995. The x-axis represents the year, and the y-axis represents the frost-free season in days from normal. The graph includes data for spring, fall, and total length, with different colors for each season. The source of the data is K. Kunkel, Midwest. Reg. Clim. Center.]
Historical Total Accumulated Ice Coverage (TAC) for the weeks 1105-0507, seasons: 1980/81-2015/16

Total accumulé de la couverture des glaces historique (TAC) pour les semaines 1105-0507, saisons: 1980/81-2015/16

Regional Great Lakes / Régionale Grands Lacs

Area / Aire : 254,689 km²
Annual Precipitation vs Year, Michigan
1895-2016
Frequency of Wet Days and Wet/Wet Days

Traverse City, MI
1900-2014

(Source: MI State Climatologist’s Office)
Mean fraction of annual precipitation derived from 10 wettest days
1971-2000

Trend in sum of the top-10 wettest days in a year (%/decade)
1901-2000

(Pryor et al., 2009)
Mean seasonal total snowfall (inches)

(Midwestern Regional Climate Center)
Past history suggests that society may be able to cope/adapt with steady climatic changes, but possibly not with changes in variability (e.g. changes in extremes, storminess)
Some Recent Extreme Weather Events in Michigan

- Heat wave, March 2012
- Major drought, summer 2012
- Wettest year on record in MI 2013
- Coldest winter in more than 100 years, 2013/2014
- Top ten coldest winter 2014/2015
- Record warm December 2015
Monthly Mean Temperature and Precipitation Departure Extremes
Michigan, 1895-2016

Temperature departures in Red
Precipitation departures in Blue
Heat Wave Frequency
Midwest Region, 1895-2012

(Kunkel et al., 2013)
Cold Wave Frequency
Midwest Region, 1895-2012

(Kunkel et al., 2013)
24-Hour Precipitation Totals (inches) for 2-100 Year Recurrence Intervals
Lansing, MI

<table>
<thead>
<tr>
<th>Recurrence Interval</th>
<th>2 Year</th>
<th>10 Year</th>
<th>50 Year</th>
<th>100 Year</th>
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<tr>
<td>TP 40 (1938-1957)</td>
<td>2.35</td>
<td>3.70</td>
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<tr>
<td>Huff and Angel (1948-1991)</td>
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<td>3.25</td>
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<td>NOAA Atlas 14 Vol. 8 (POR, 2013)</td>
<td>2.43</td>
<td>3.42</td>
<td>4.80</td>
<td>5.50</td>
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Growing Season Drought Severity
Michigan, 1895-2016

(Source: NOAA/NCEI, 2017)
Major Weather-Related Disasters, 1980-2016

Billion-Dollar Disaster Event Types by Year (CPI-Adjusted)

- Winter Storm
- Wildfire
- Flooding
- Trop Cycl
- Severe Storm
- Freeze

Number of Events vs. Cost in Billions of Dollars

Cost w/ 95% CI and 5-Year Mean

Years: 1980 to 2016
Future Projections
Observed and Projected Temperature Change

Michigan

- Observations
- Modeled Historical
- Higher Emissions
- Lower Emissions

Temperature Change (°F)

Year

1900 1925 1950 1975 2000 2025 2050 2075 2100

Higher Emissions
Lower Emissions

(NCICS, 2017)
Projected Temperature-Related Changes
2041-2070 vs. 1971-2000

(Pryor and Scavia, 2013)
Region projected to become wetter, largely as a result of increasing cold season precipitation

Source: (IPCC, 2007)
Projected Precipitation-Related Changes
2041-2070 vs. 1971-2000

(Pryor and Scavia, 2013)
Projected Great Lakes Levels

More recent results by Lofgren et al. (2011) and Gronewold et al. (2013) suggest smaller changes in future lake levels.

(Hayhoe et al., 2010)
(Angel and Kunkel, 2010)
Summary

• Overall, mean average temperatures in Michigan rose approximately 1.0ºF during the past century. Warming of about 2.0ºF has occurred between 1980 and the present.
• Milder winter temperatures have led to less ice cover on the Great Lakes and the seasonal spring warm-up is occurring earlier than in the past.
• Annual precipitation rates increased from the 1930’s through the present, due both to more wet days and more extreme events.
• Most recent GCM simulations of the Great Lakes region suggest a warmer and wetter climate in the distant future, with much of the additional precipitation coming during the cold season months.
• Projections of future climate change in Michigan suggest a mix of beneficial and adverse impacts.
• A changing climate leads to many potential challenges for dependent human and natural systems, especially with respect to climate variability.
• Given the projected rate of climate change, adaptive planning strategies should be dynamic in nature.
Thank You!